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Materials & Methods

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EDITORIAL

Help Instead of Hinder Steel Output

As a recent newspaper article pointed out, some people are of the opinion that anything can be achieved by passing a law. That feeling now seems to have reached some government planners, at least if their threats and plans in connection with steel can be interpreted correctly.

Although the steel industry will have reached the 10-million-ton capacity increase recommended by government and labor by the end of this year, this effort still meets with official criticism. Therefore, a law is threatened which will permit the government to go into competition with private industry.

Aside from the political and sociological aspects of such a threat, there are several practical considerations which seem to have been overlooked. Even though there were to be more steel making capacity in terms of physical plant, where are the required labor, raw materials, management and customers going to come from?

Rather than harassing the steel industry, which seems to be a favorite whipping boy, wouldn't it be much more sensible to take positive steps to help relieve current problems?

The following steps could be taken by the government at moderate cost—at least moderate as compared to building new capacity.

1. The government could find more coking coal through efforts of the Bureau of Mines.

Production rates and steel making costs have both suffered because of a lack of suitable coking coals of the type used by steel makers. Previous sources are becoming depleted. The Bureau of Mines is better equipped to carry on further explorations and tests than are private companies.

2. Help develop the scrap supply.

Some steps are now being taken in this direction under direction of the Department of Commerce. Although the scrap situation has improved, there is still a need to provide adequate scrap stockpiles. The combined stock of scrap and pig iron is still below desirable levels.

3. Find dependable sources of manganese.

We now rely heavily on the Soviet for manganese ores. Indications are that this source of supply will be reduced or shut off entirely as a move in the cold war. To prevent a crippling of the steel industry, other ore sources are needed promptly.

4. End the pricing muddle.

Expansion in historical steel centers will be seriously curtailed as long as confusion exists in our present laws covering pricing of finished goods. In addition, clear cut laws on pricing will be necessary before any new locations are chosen for steel mills, since permissible pricing systems will have a great bearing on the most practical areas of doing business.

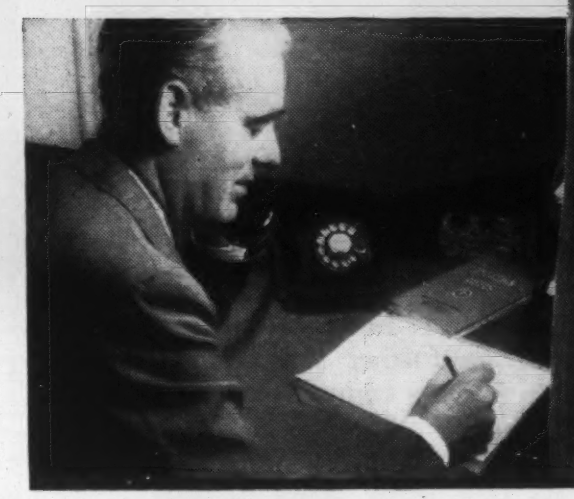
5. Quit threatening the steel industry.

Since the steel industry, by its very nature, is big, it seems to be the first target for governmental attack. If the time, brains, and money spent to defend itself could be used to improve the steel industry we would all benefit.

T. C. Du Mond
Editor

Howard Allen, *Inspector*

Howard Allen, *Lab. Man*



Howard Allen *on Order Desk*

Howard Allen, *Sales Representative*

Howard Allen, *Machine Operator*

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RYERSON STEEL

Materials & Methods

FEBRUARY 1949

Progress in Titanium Told at Naval Research Symposium

Here is an account of some important recent findings about the production, properties and possible applications of that promising metal of the near future, titanium, as reported by leading authorities in the field.

by T. C. DU MOND, Editor, Materials & Methods

• THE INTENSE INTEREST which has been built up in titanium metal during the last two years was climaxed one day recently when two symposia were held on the subject. In Washington, D. C., the Office of Naval Research sponsored a symposium, while in New York the American Institute of Mining & Metallurgical Engineers had a similar session. This report will confine itself to the Washington gathering, which was attended by approximately 200 representatives of industry and government.

Several truths became evident through the 17 papers presented before the Washington symposium. For instance, titanium is a metal destined to become highly important in the future, even though it may not be the "Cinderella Metal" that someone dubbed it. While there is still some doubt as to the physical characteristics of titanium, it is certain that the metal has a favorable strength-weight ratio. Likewise, the corrosion resistance of the material is comparable to Hastelloy C and platinum. At the present time the uses for which titanium is destined appear to be on aircraft and marine products.

Papers given at the Washington meeting were presented under the following classifications: Research and Development Programs on Titanium; Production and Properties of Titanium Metal; Alloys of Titanium; and, Physical Metallurgy of Titanium and Its Alloys.

Representatives of the Army, Navy and Air Force reported that the armed services are actively investigating the uses of titanium. Research of the services is being augmented by sponsored programs carried on by several other organizations. Although the military groups are primarily interested in titanium for aircraft uses, it has practically assured itself a place in marine craft for such assignments as condenser tubes, salt water piping, plumbing fixtures, pump rods and anti-friction bearings running in sea water.

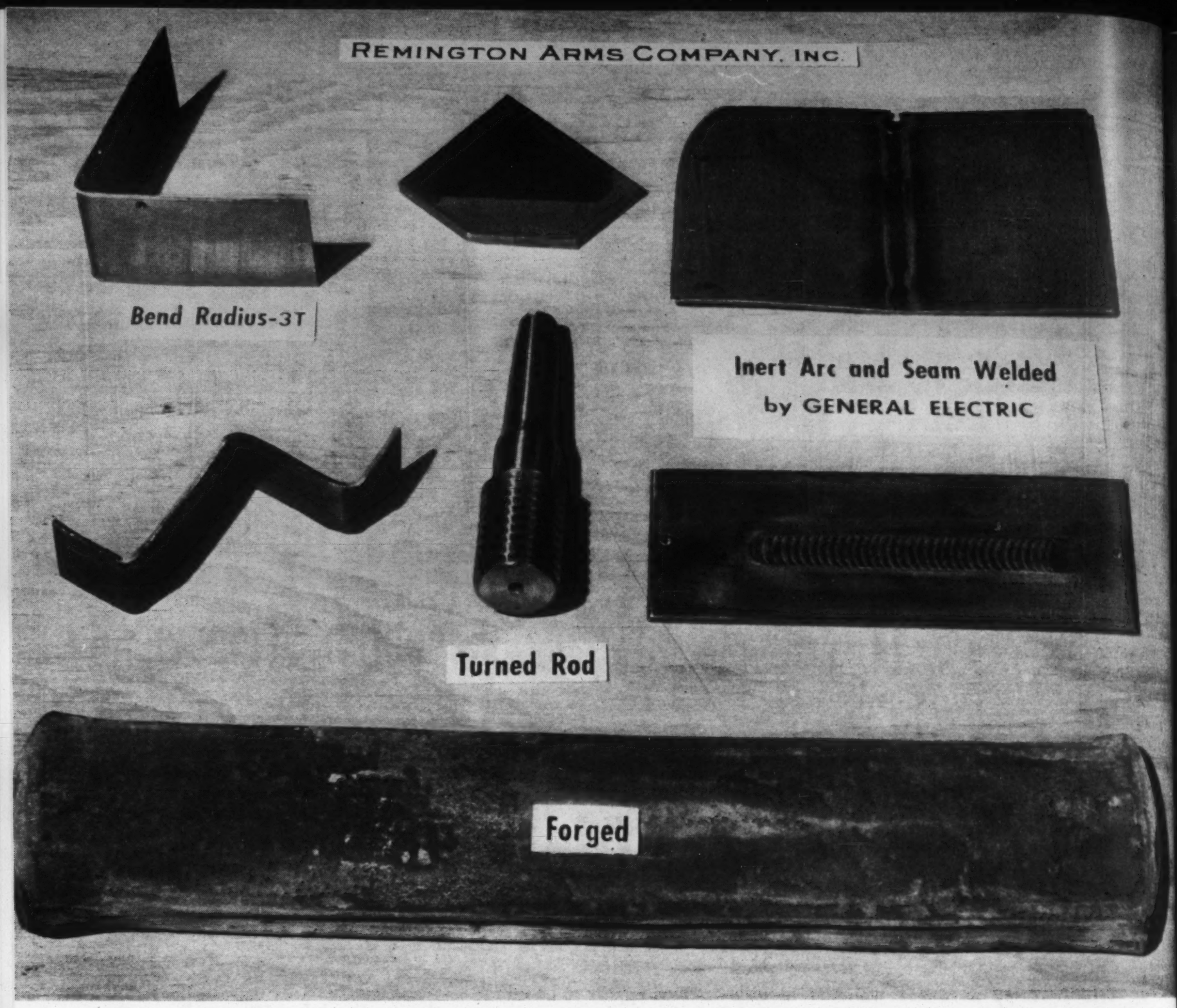
Production seems to be the crux of the problem relative to a rapid development of titanium. Production now is limited, thus the price of titanium is in the neighborhood of $5.00 per lb. Predictions are that the metal will be produced for 50¢ per lb. in the not too distant future.

At present there are at least four methods of producing the metal. Properties attained vary somewhat with the basic production method, making difficult any definite statement of physical properties.

The U.S. Bureau of Mines favors the Kroll process of producing titanium metal. This process involves a reaction between titanic chloride and magnesium, which produces a spongy titanium metal. The spongy metal is then ground and purified, ready to be formed by powder metallurgy methods into a metal ready to be rolled into usable form.

Battelle Memorial Institute and Foote Mineral Co. combined efforts to produce titanium by the iodide process used to prepare other high purity metals. While this method is ideal for producing titanium of great purity, it cannot be considered as a potential high production method.

E. I. du Pont de Nemours & Co. reported on the induction melting of titanium metal in graphite crucibles



Titanium can be fabricated by most of the common forming methods. Shown here are pieces of machined, formed, forged and welded titanium. (Courtesy: The Remington Arms Co.)

as a means of consolidating the powders as opposed to powder metal means. Finally, another project of Battelle Memorial Institute was described. This is the arc-melting of titanium.

It can be seen from the lines of investigation being followed that it is desirable, if possible and practicable, to produce the metal in cast or other solid form without passing through the powder stage. Slight impurities of certain types appear to have a profound effect on the final properties of the metal.

Alloy Development

As is the case with most metals, alloying is expected to produce the most desirable combination of properties. P. R. Mallory & Co., Inc., reported on its alloying investigations which covered the use of hydrogen, beryllium, boron, aluminum, indium, carbon, silicon, zirconium, nitrogen, vanadium, oxygen, chromium, molybdenum, tungsten, manganese, iron, cobalt and nickel as alloying elements.

From these investigations, it was concluded that the following have characteristics which might be of practical value:

- alloys containing up to 5% aluminum
- alloys containing about 5% manganese
- alloys containing up to 1% beryllium
- alloys containing up to 1% boron
- alloys containing up to 1% silicon

Most of the elements listed as alloy possibilities increase the tensile strength of titanium by important amounts, some improve cold working properties, while aluminum improves

Comparative Properties of Titanium

	Iodide Type		Kroll Process	
	Annealed	Cold Rolled	Annealed	Cold Rolled
Ultimate Strength, Psi.	32,000	170,000	80,000	120,000
Yield Strength, 0.2% Offset, Psi.	17,500	90,000	64,000	113,000
Elongation, % in 2 In.	55	2.5	25	7.5
Reduction of Area, %	60	30	—	—
Modulus of Elasticity, Psi.	11,200,000	16,200,000	—	—

both hot and cold working properties and increases titanium's resistance to oxidation.

Westinghouse Electric Corp. research laboratories have completed considerable work to test the high temperature properties of titanium and titanium alloys. In this work over 50 different alloys were induction melted and cast. Among the conclusions of Westinghouse is that at 1750 F the best 0.2% yield strengths were found in titanium-chromium alloys which contained molybdenum and tungsten in equi-atomic ratios.

The Remington Arms Co., Inc., a du Pont affiliate, is engaged in an extensive program to develop and produce titanium and titanium-base alloys in fabricated forms. A report on this company's findings was presented to the symposium. Remington describes titanium as possessing "a combination of the properties of aluminum alloys and stainless steel."

Remington research confirms the reports that commercially pure titanium is readily forged with a 1600 to 1800 F temperature range. Machinability is similar to that of austenitic stainless steels, using the same type tools, speeds and feeds. Other investigations show that titanium is readily spot welded, seam welded and joined to other pieces of titanium by means of inert-gas shielded arc welding.

Laboratory tests on titanium's chemical corrosion resistance indicate that titanium is resistant to the following:

Nitric acid at 25 c in all concentrations up to 95%
Nitric acid of 65% concentration at 55 c to boiling
Relatively dilute warm hydrochloric acid
Relatively dilute warm sulfuric acid
Aqua regia at 30 c
Water saturated with chlorine at 80 c
Chlorine saturated with water at 80 c
Bleach solution at 30 c
Ferric chloride, 10% solution, boiling
Calcium chloride, 28% solution, boiling
Sodium hydroxide, 10% solution, boiling

Although the summary which follows is largely that of the Remington Arms Co., it seems to agree closely with the opinions of others taking part in the symposium.

Commercially pure titanium provides a material between aluminum alloys and stainless steel as to modulus, density and strength at intermediate temperatures.

Titanium's strength-weight ratio is favorable over aluminum alloys and stainless steel in specific applications. Where titanium can be substituted directly section-for-section in place of stainless steel, a weight saving of 40% will result.

Titanium's sea water and marine atmospheric corrosion resistance is better than austenitic stainless, Monel, and the cupro-nickel alloys and equal to that of platinum and Hastelloy C.

Because of these combinations of properties, immediate uses of commercially pure titanium could be made in airframe skins and structures; aircraft power plants where temperatures between 300 and 800 F are involved; naval and marine applications; industrial equipment where corrosion resistance is needed; and miscellaneous applications in which a combination of light weight, corrosion resistance, high strength and good intermediate temperature properties are required.

Comparative Properties, Titanium, Aluminum Alloy and Stainless Steel

	Titanium	75ST Aluminum	18:8 Austenitic Stainless Steel
Density, gm./cc	4.5	2.8	7.9
Young's Modulus, Psi.	15.5×10^6	10.3×10^6	28×10^6
Melting Point, deg. F	3140	1220*	2800*
Thermal Expansion, per deg. F	5.0×10^{-6}	12.7×10^{-6}	9.5×10^{-6}
Electrical Conductivity, % I.A.C.A.	3.2	30	2.5
Thermal Conductivity, BTU/ft.^{2}/in./deg. F/hr.	105	835	115

* *For pure iron and pure aluminum.*

Papers Presented at Titanium Symposium Sponsored by Office of Naval Research

Research and Development Programs on Titanium

1. "The Bureau of Aeronautics Titanium Program," N. E. Promisel, Materials Branch, Bureau of Aeronautics, Navy Dept.
2. "Activity of the Wright-Patterson Air Force Base in Developing Titanium," J. R. Burns, Materials Laboratory, Air Materiel Command, Dayton, Ohio
3. "Titanium Program of Army Ordnance," L. S. Foster, Watertown Arsenal, Office of Chief of Ordnance, U. S. Army

Production and Properties of Titanium Metal

4. "Production of Titanium Powder at Boulder City," F. S. Wartman, Boulder City, Nev. Division, Bureau of Mines
5. "A New Method of Consolidating Titanium Powder," J. R. Long, College Park, Md. Division, Bureau of Mines
6. "Physical and Mechanical Properties of Commercially Pure Titanium," C. I. Bradford, Remington Arms Co.
7. "Production and Properties of Iodide Titanium," B. W. Gonser, Battelle Memorial Institute
8. "Properties of Iodide Type Titanium," F. B. Litton, Foote Mineral Co.
9. "Induction Melting of Titanium Metal in Graphite," J. B. Sutton, Pigments Dept., E. I. du Pont de Nemours & Co., Inc.
10. "Production and Arc-Melting of Titanium," L. W. Eastwood, Battelle Memorial Institute
11. "Some Preliminary Tests to Determine Applications of Titanium," W. Lee Williams, U. S. Naval Engineering Experiment Station

Alloys of Titanium

12. "Some Preliminary Data on Alloys of Titanium," E. I. Larsen, P. R. Mallory & Co., Inc.
13. "Titanium-Base Alloys," H. C. Cross, Battelle Memorial Institute
14. "Some Aspects of the Metallurgy of Titanium Alloys," P. H. Brace, Westinghouse Research Laboratories

Physical Metallurgy of Titanium and Its Alloys

15. "Description of Apparatus for the Melting of Titanium and for the Study of the Titanium-Oxygen System," E. J. Chapin, Metallurgy Div., Naval Research Laboratory
16. "The Carbon-Oxygen Relationship in Titanium Melted in Carbon Refractories," S. F. Urban and A. C. Haskell, Titanium Alloy Manufacturing Div., National Lead Co.
17. "First Progress Report on Titanium—Carbon and Titanium—Nitrogen Phase Diagrams," John P. Nielsen, College of Engineering, New York University

Induction Hardening Increases Wear Life of Cast Iron Parts

That cast irons can be successfully induction hardened to give improved performance is shown here by descriptions of a number of applications.

by H. R. CLAUSER, Associate Editor, Materials & Methods

● INDUCTION HEATING provides an attractive method for locally hardening cast irons. Although not yet used as widely as on steel, its application to cast irons is increasing as more knowledge about its possibilities becomes available.

Induction heating being a high-speed process, it is most suitable and economical where the heating cycle is relatively short. For this reason, it has proved satisfactory for many steel hardening applications. Cast iron, however, does not respond as quickly to heat treatment. Unlike steel, a good part of its carbon is present in an uncombined state as graphite, and its substantially higher silicon content adds to this graphitizing effect. Therefore, in hardening unalloyed cast iron, it may be necessary for it to be held for a longer period at the hardening temperature in order to get at least part of the carbon back into solution. Since induction hardening generally is not practical when the hardening cycle exceeds 1 min., the problem in induction hardening cast iron is that of finding ways of minimizing this time factor.

The length of time at the quenching temperature depends largely on the amount of combined carbon present prior to the heat treatment. Thus, to obtain a given hardness, the smaller the amount of combined carbon, the longer the iron must be held at the quenching temperature. Therefore, the combined carbon, and the metallurgical structure of cast iron before hardening, is of great importance and must be carefully controlled right in the foundry to obtain high and uniform hardness with reasonable heating ratings. For optimum results, it has been found that: (1) the combined carbon should be from 0.50 to 0.80%, (2) the graphite should be in a fine condition and well distributed, and (3) the matrix should be pearlitic or sorbitic. In addition, the quality of the castings must be such that no porosity, shrinks, sand holes or other heterogeneous areas are present, particularly in or near the surface. If present they can cause localized overheating and subsequent rupture at that point.

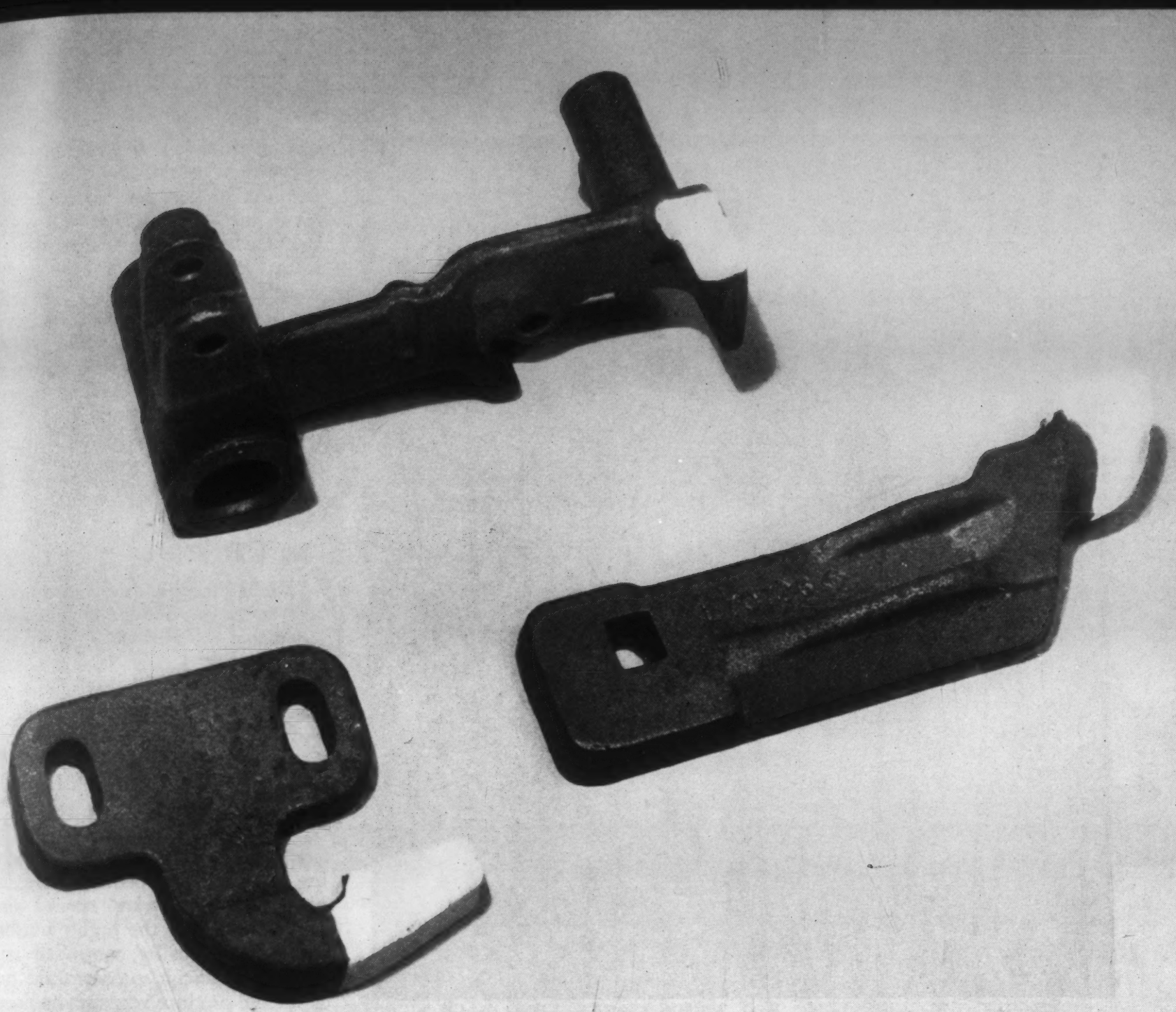
All the common types of cast iron, including plain and alloyed gray iron, and pearlitic and malleable cast iron can be induction hardened. However, some of these are more easily hardened than others, depending largely on their composition and metallurgical structure, as mentioned above.

Quality Controlled Iron

Quality controlled iron, commonly known as Meehanite metal, is a gray cast iron in which both the quantity and form of graphite in a pearlitic matrix is precisely controlled. Therefore, its as-cast structure responds readily to the rapid heating inherent with the use of induction heating. The composition of these irons in general runs around 3.0% total carbon and around 1.5% silicon.

Recent work by Walton and Osborn has brought out a number of the characteristics and advantages of these induction hardened high quality irons. They found that hardness values of 55 to 60 Rockwell C can be readily obtained in production. It was also found that quality controlled irons are particularly well suited to case hardening by induction. Control of depth hardness is not difficult, and shallow depths of case from 0.030 to 0.040 in. are obtainable without loss of strength.

Their results show that transverse strength increases above the as-cast strength with case depths up to 0.100 in. on a 0.800-in. dia. and up to 0.200 in. on a 1.2-in. dia. Above this, strength decreases with an increase in case depth; in through-hardening, without subsequent drawing, strength is reduced about 30%. The decrease in strength on through-hardened parts is to be expected, since a lower strength always results when gray iron is through-hardened by quenching, regardless of the heating method used. Tempering usually brings the strength back to the as-cast figure or higher, depending upon the temperature, without an appreciable loss of hardness. The problem of distortion was also considered, and results showed that distortion occurring in



These plain gray iron parts had improved wear resistance after being selectively induction hardened as indicated in white. Upper, transferrer; lower left, lay guide follower; lower right, bunter.

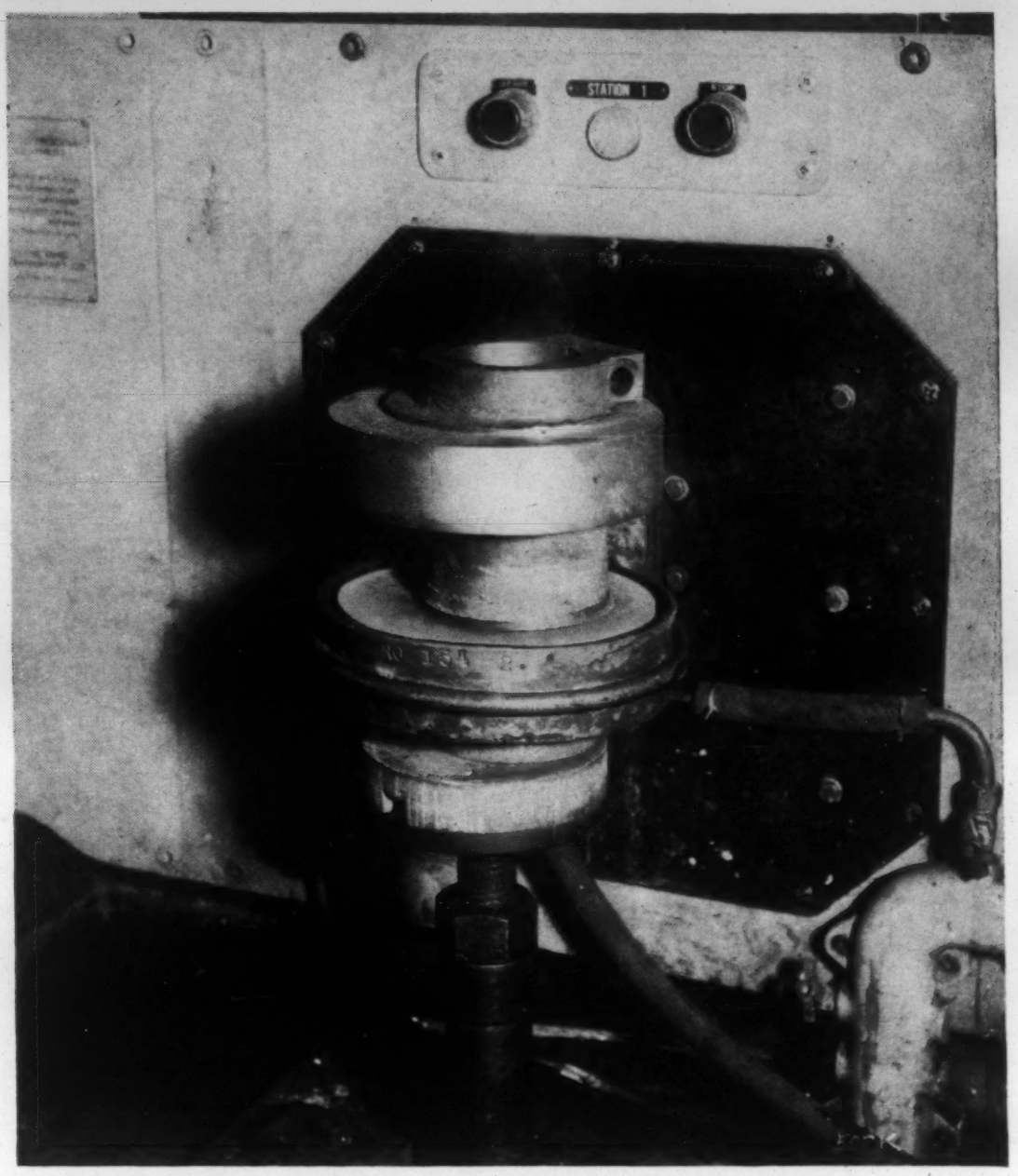
induction hardened parts was much less than that by furnace heating.

There have been a number of successful practical applications of induction hardening high quality cast iron parts in recent years. One of the outstanding ones is the hardening of Diesel engine liners by the General Foundry & Manufacturing Co. for the Budd Wheel Co. The inside surface of the liners, ranging in size from 5 to 30 lb. and from ⅜- to ⅞-in. thick, are induction hardened to give a martensitic structure with a hardness of from 50 to 55 Rockwell C. The depth of hardness is controlled to any desired amount, although the usual depth is ⅛ in.

The liners are heated to about 1600 F and spray quenched with water. The hardening procedure consists of moving an induction heating coil through the sleeve bore. As the coil moves along, the inside surface of the sleeve is raised to the hardening temperature and immediately quenched. For a sleeve 15 in. long, this hardening cycle is about 9 sec. No subsequent drawing treatment is required.

A variety of high quality cast iron parts are being induction hardened by the Continental Gin Co. One is an oil engine cam used for fuel oil injection. The part was formerly made from tool steel bar stock, hardened and ground all over. By using quality controlled iron and hardening by induction, the cost was reduced approximately 50%. The outside surface of the cam is induction hardened to a hardness of 48 to 52 Rockwell C. The heating cycle is 58 sec., and a dip quench of oil is used. Another cam, used on knitting machines, is induction hardened to 48 to 52 Rockwell C on its contacting surfaces. The heating cycle on this part is 70 sec., and it is dip quenched in oil. A brake drum, also used on a knitting machine, is case hardened to 45 to 50 Rockwell C, using a heating time of 60 sec., and an oil quench.

Another interesting application is that of double flanged conveyor wheels made of high quality cast iron by Banner Iron Works and induction hardened by Lindberg Steel Treating Co. for the National Engineering Co. To harden the tread of these wheels, they are placed on a shaft arrangement in a split inductor block and rotated by means of compressed air. The wheels are turned during the entire heating cycle of 5 min. to obtain a uniform temperature and assure uni-



A knitting machine cam of Meehanite metal being induction hardened.

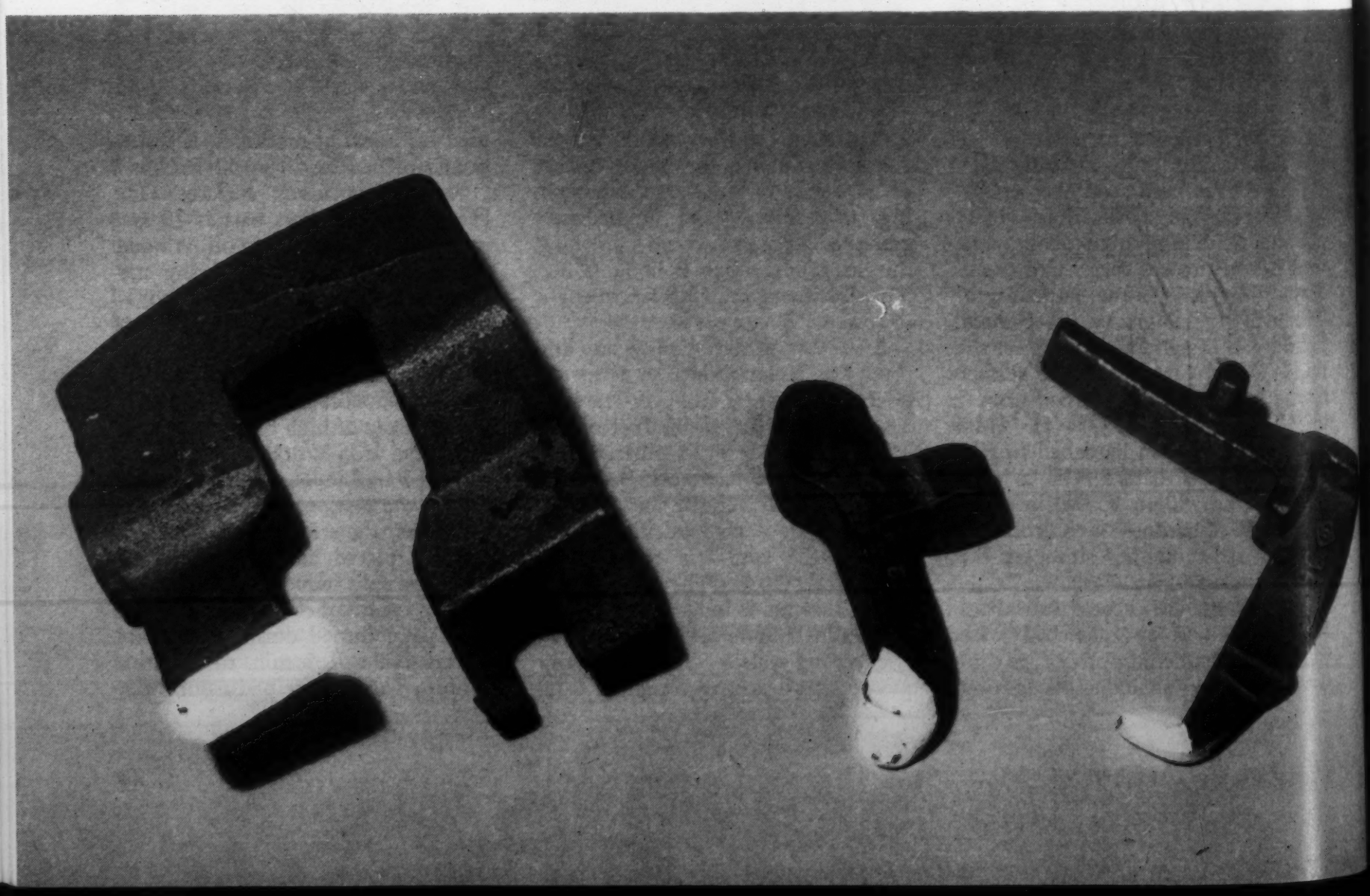
form hardness upon quenching. Compressed air is played on the flanges in order to keep them from heating above the critical. The tread surface is quenched with a stream of water from a temperature of 1550 F. The wheels are then tempered at 350 F for 3 hr. The final hardness of the treads is 48 to 52 Rockwell C.

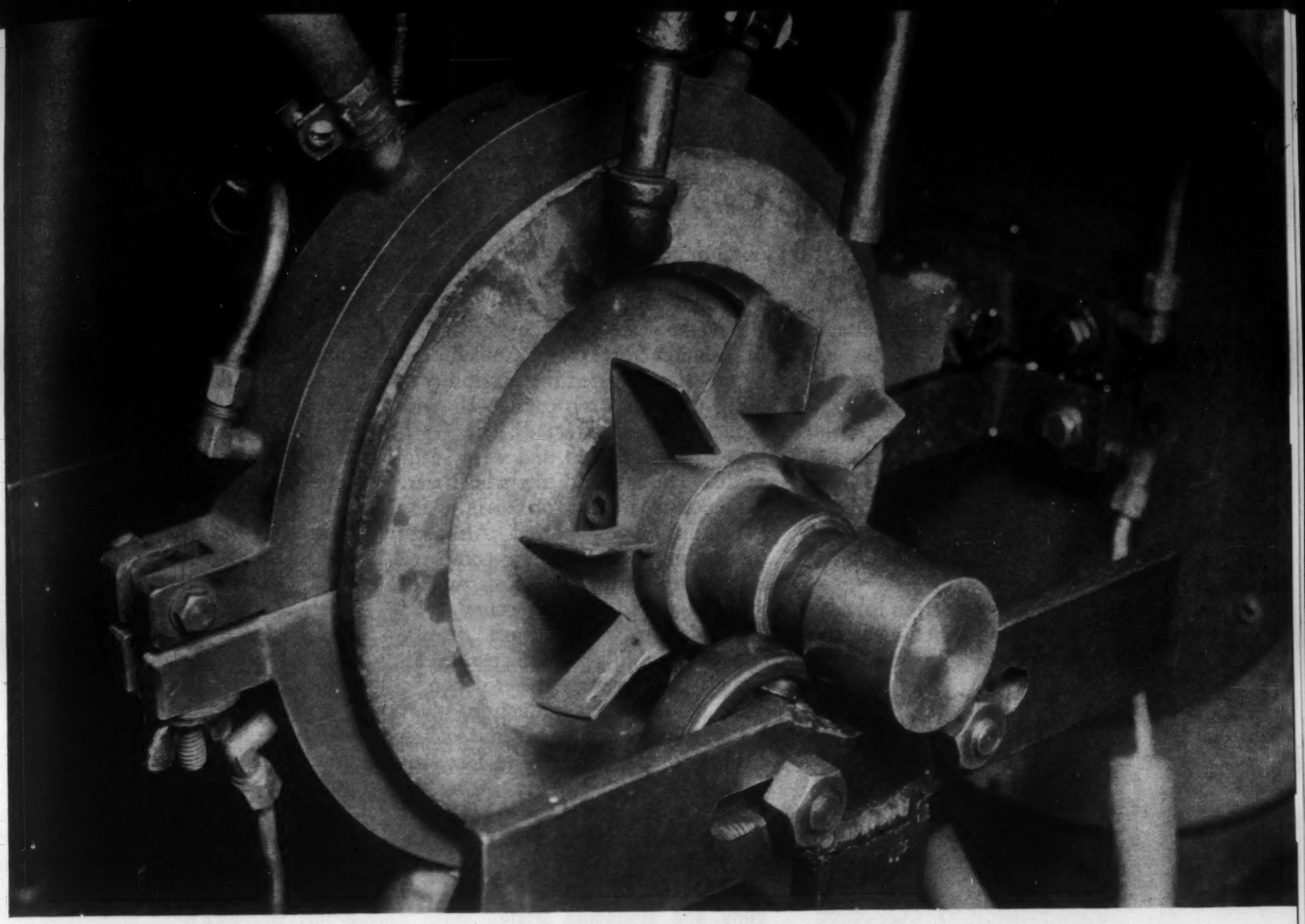
These wheels are used in foundry conveyors and are subject to considerable abrasion from sand. Since they have been hardened by induction, their life has been significantly increased.

Plain Gray Iron

While quality controlled iron is the best suited for induction hardening, for many applications ordinary gray cast iron can also be successfully induction hardened if steps are taken to assure correct structure prior to hardening. This involves a careful control in the foundry of the composition and of the melting and pouring to secure a sufficient amount of combined carbon to obtain the desired hardness with a practical hardening time and temperature. Because plain gray irons are not as fine-grained and lack the highly uniform structure of quality controlled iron, it is more difficult to control the case depth and produce very thin hardened layers.

Typical plain gray iron parts for textile machinery that have been induction hardened in spots indicated in white. Left, bobbin support; center, clutch finger; right, thread cutter.





Shown here in the induction hardening jig is a double flanged wheel made of quality controlled cast iron. The wheel is rotated in the induction coil by compressed air.

One of the largest manufacturers of textile machinery is successfully induction hardening 700 different plain gray iron parts. The total annual output runs around 2,000,000 pieces. The parts include feed pawls, thread cutters, cams, clutch fingers and the like, and they are selectively hardened in certain critical areas to increase their wear resistance. A few typical parts are shown in the accompanying photographs. The hardened portions of these parts are painted white.

The parts shown range in size from the clutch finger and thread cutter, whose greatest dimension is about 3 in., to the transferrer, whose largest dimension measures 7 in. As can be seen, the shape, area and thickness of the hardened portions vary considerably, depending on the part. The thinnest hardened section, which is on the thread cutter, is approximately ¼ in. The heavier parts have hardened sections up to about ¾ in. The Rockwell hardnesses of the hardened and unhardened portions of the illustrated parts are given in the accompanying table.

The material used for these parts is plain gray cast iron having about 3.5 carbon, around 2% silicon, and containing no alloy additions. By careful control of foundry practice, a structure having the necessary combined carbon for satisfactory induction hardening is obtained. The importance of melting and foundry practice to get a suitable prior structure is illustrated by the fact that another cast iron parts producer using an iron of the same composition and the same hardening procedure failed to obtain satisfactory hardnesses.

The induction hardening cycle for most of the parts is essentially the same. The portion to be hardened is heated to between 1550 and 1700 F, then quenched with oil either by spraying or immersion. Water is sometimes used if it is desirable to quench from a lower temperature. The hardening cycle is quite rapid, making the method suitable for production work. For example, using one induction heating unit the rate of hardening the bobbin supports is 800 per hr.; thus, in this case the heating cycle was about 5 sec. Depending upon the application, the part can be tempered. Parts subject to impact are frequently given a low temperature draw to increase their shock resistance.

In the old method the parts were locally hardened during the casting operation by the use of chills. The chills were so placed that upon pouring, the portions to be hardened cooled rapidly. Using this method the cooling rate was often difficult to control properly and the desired hardness not always obtained. As a result, rejects ran up to 15% and more on some jobs. After induction hardening was adopted, the rejects were cut

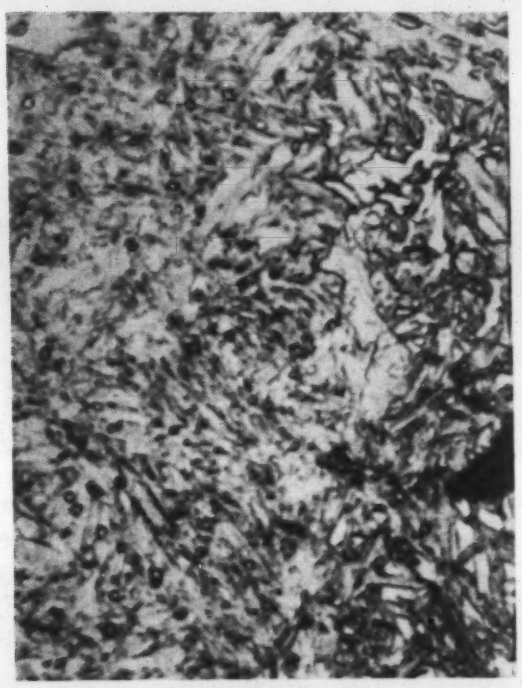
Hardnesses of Gray Iron Parts Before and After Induction Hardening

Part	Induction Hardened R_c	Unhardened R_c
Lay Guide Follower	52-54	13-15
Thread Cutter	50-59	18-20
Clutch Finger	50-58	17-20
Bunter	55 (approx.)	16 (approx.)
Transferrer	56 (approx.)	16 (approx.)
Bobbin Support	55 (approx.)	16 (approx.)

down to around 2% and less. The elimination of chills greatly simplified the foundry procedure and reduced pattern costs. The labor costs involved in making, setting and reclaiming the chills were also eliminated.

In some cases design advantages are realized. For example, on the transferrer part the location of certain drilled holes is critical, and the location must be made by reference to the hardened area. By the old method it was necessary to locate the hole from the rough, chill hardened surface. By adopting induction hardening, the area is machined and the hole located before hardening.

While the use of induction hardening in place of chill hardening in the mold is desirable in many cases be-



This microphotograph shows a typical martensitic structure obtained near the surface of an induction hardened Meehanite metal part (Nital etch—1500X).

cause of one or more of the advantages just mentioned, the type of service to which the part will be subjected must be carefully considered, for the two methods of hardening do not produce identical properties. In general, chilled parts contain more carbides and have somewhat higher hardnesses and wear resistance than induction hardened parts that are essentially martensitic. The hardness of chilled parts is also more stable than that of induction hardened parts at elevated temperatures. This is due to the fact that the carbides are stable even at temperatures where the heat draws the hardness produced by heat treating. In addition, chilled iron has a lower coefficient of friction against some materials.

Induction hardening is also adaptable to relatively large gray iron castings, where larger surface areas are involved. However, the problems of obtaining satisfactorily hardened parts economically becomes increasingly difficult with larger areas.

Several years ago, the Association of Manufacturers of Chilled Car Wheels investigated the possibility of using gray cast iron car wheels with induction hardened treads. These castings weighed 750 lb. and were 33 in. in dia. The treads of the wheel were hardened to a depth of 0.5 in. using a 12-min. heating period. Although the heating cycle was long compared to that for small parts, a casting of this size would require around 5 hr. to harden by conventional furnace methods. In this particular case, although the car wheels were successfully hardened by induction, their actual use in service has not developed, primarily due to the fact that the heat generated in service by the brake shoes proved to be great enough to draw the hardness.

Alloy and Malleable Irons

It is well known that additions of alloying agents, such as chromium, nickel, molybdenum and vanadium, can have a marked effect on the response of gray cast irons to hardening treatments. When added in sufficient quantities they facilitate carbide formation.

Cylinder liners for large internal combustion engines made of mildly alloyed cast iron are being successfully induction hardened, as reported by Sloan and Hays. The iron has about 3.00 carbon, 2.00 silicon, 2.00% nickel and less than ½% each of chromium, molybdenum and copper. The inside surface of the liners are hardened to a depth of from 0.060 to 0.085 in. The hardness of the surface after induction hardening ranges approximately from 47 to 55 Rockwell C. The induction hardening cycle runs about 2 sec.

Although malleable iron can be hardened, it is difficult to induction harden without a preliminary heating. Malleable iron consists largely of a ferritic matrix and temper carbon. The temper carbon is nodular shaped graphite as distinct from the flaky form which is present in gray iron. Since this temper carbon is rather widely dispersed, it requires a longer period for diffusion to obtain a high and uniform hardness.

Pearlitic malleable iron, on the other hand, is well suited to induction hardening. Pearlitic malleable contains combined carbon in various forms. The carbides are finely divided and dispersed uniformly, so that upon heating to hardening temperatures they readily dissolve in gamma iron. Thus, by induction hardening, high and uniform hardnesses can be achieved. The ability to control the amount of combined carbon and its ideal structure makes it possible to closely control both the depth and degree of hardness.

The Packard Motor Car Co. has been using induction hardened pearlitic malleable iron camshafts since 1937. Prior to that time carburized steel forgings, and induction hardened steel forgings were used, and for a limited time flame hardened alloy cast iron. The reasons for adopting induction hardened pearlitic malleable were: (1) lower cost, (2) extremely good service results, and (3) quieter operation compared to steel.

The malleable iron used for these camshafts has a combined carbon range from 0.55 to 0.80, and a uniform microstructure of temper carbon evenly dispersed hardening cycle for the full circumference of the cam is: heating to temperature, 4.4 sec.; delay at temperature, 7.4 sec.; and quench, 5.5 sec. This particular cycle with a 2000-cycle generator gives a Scleroscope reading of 75 minimum and a hardened depth of around ¼ in.

The applications described in this article indicate that induction hardening of cast iron can be successfully done if the metallurgical factors of combined carbon and structure are carefully controlled prior to hardening. Therefore, where local hardening or a hardened case would increase the wear life of a cast iron part, it would be well to investigate the possibility of induction hardening.

In addition to those mentioned in the text we wish to thank the following organizations for their help in the preparation of this article:

Induction Heating Corp.
Ohio Crankshaft Co.
Meehanite Metal Corp.

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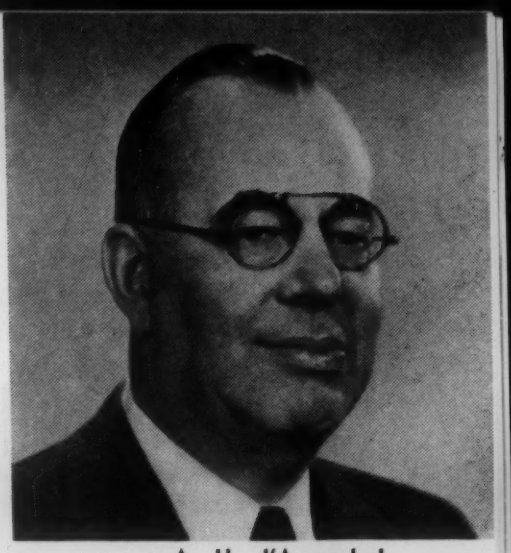
C. F. Walton and H. B. Osborn, Jr., "Induction Hardening of a Quality Controlled Iron," *Transactions of American Society for Metals*, Vol. 40, 1948, p. 1012.

J. R. Sloan and R. H. Hays, "Some Factors Affecting the Induction Hardening of an Alloy Cast Iron," *Transactions of American Society for Metals*, Vol. 40, 1948, p. 1036.

Materials & Methods Article Awarded First Prize in IFMA Competition

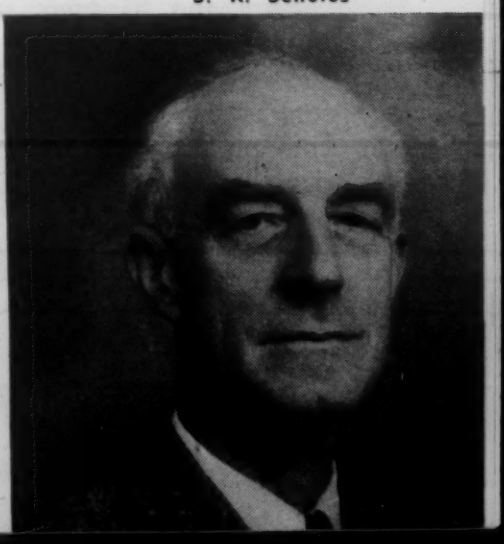


A. H. d'Arcambal

E. S. Davenport

George W. Mason

R. E. McGee



S. R. Scholes

A MATERIALS & METHODS author has been awarded the $1,000 first prize in the recently concluded competition of the Industrial Furnace Manufacturers Association. The contest, designed to foster the presentation of specific operating data on furnace, oven and kiln installations, attracted 105 articles published in 15 magazines.

The author so rewarded was Floyd J. Kamin, president of the Kamin Die Casting & Mfg. Co., Chicago. His article, entitled "Two-Chamber Induction Melting Furnace Lowers Aluminum Die Casting Cost," was published in the September 1948 issue of MATERIALS & METHODS.

The award presentation was made at a dinner in Cleveland, Ohio, at which time the other prize winners were also given their awards. Editors of the three magazines publishing the articles were likewise given suitable awards.

Winner of the second prize in the competition was Thomas A. Frischman, Chief Metallurgist, Axle Div., Eaton Manufacturing Co., Cleveland. Mr. Frischman received a $300 award for his article "Controlled Atmosphere Cycle Annealing," published in the Sept. 9, 1948 issue of *The Iron Age*.

Third prize of $200 went to I. Stanley Wishoski of the National Industrial Publishing Co., Pittsburgh. Mr. Wishoski's article, published in *Industrial Heating*, of which he is editor, in October 1947 was entitled "Continuous Carburizing and Hardening of Piston Pins at the Ford Rouge Plant."

Presentations at the award dinner were made by Mr. W. E. Borbonus, President, R-S Products Corp., Philadelphia, and chairman of the Association's public relations committee.

Judges of the competition were:

A. H. d'Arcambal,
Vice President-Consulting Metallurgist
Pratt & Whitney
Division Niles-Bement-Pond Co.
West Hartford, Conn.

E. S. Davenport,
Assistant to Vice President
United States Steel Corp.
Pittsburgh, Pa.

George W. Mason, President
Nash-Kelvinator Corp.
Detroit, Mich.

R. E. McGee, Manager
Metallurgical Research
International Harvester Co.
Chicago, Ill.

S. R. Scholes, Associate Dean
The New York State College of Ceramics
Alfred University
Alfred, N. Y.

At the dinner, C. H. Stevenson, Vice President, Lindberg Engineering Co., Chicago, and president of IFMA, thanked the business paper editors for their cooperation through this contest in helping to make American industry more conscious of the economies of production that are possible through the use of modern furnace and oven equipment.

Compressed Wood-Fiber Sheets Useful as Engineering Materials

Manufactured wood sheets, commonly known as Masonite, have fabricating characteristics that suit them to both mass and small quantity production of a variety of products.

by EDWIN LAIRD CADY

● MASONITE hardboards are manufactured wood sheet products made entirely of exploded wood fiber. They, as a class, provide an engineering material having applications in many industries not only as a basic material for a variety of consumer products, but also as a die material for forming and fabricating certain metals.

Hardboards are made by filling a chamber with wood chips, closing the chamber, introducing into the chamber steam high enough in pressure to displace the air between the fibers of the wood and evacuating the wood abruptly to the open air so that the imprisoned steam will separate the wood fibers. The fibers then are washed, refined, felted and pressed into boards of the desired thickness and density. No artificial binder is added. Only the lignin, natural bonding agent of wood, is used to re-weld the fibers together.

Types of Hardboards

Hardboards can be made low in density and hardness for insulation boards, or they can be made dense and hard enough to be used in dies for the shaping of sheet metals, or to any gradient between these two. Various controlled characteristics also can be given to hardboards by selecting various combinations of hard and soft woods for their original production, and by other procedures.

There are a number of types of hardboards, designed to meet various application requirements. The hardest and densest of all is Die Stock. This product approaches the ultimate density of lignocellulose fibers with an average specific gravity of 1.41. That of lignocellulose is 1.45. Its weight is about one-sixth that of steel in equal volume. It is practically inert to expansion or contraction.

Die Stock is used in tools for bending and stretching sheet metals, in forming blocks, mechanical dies, assembly and drill fixtures, welding fixtures, router templates, spinning chucks, and in many other ways such as for cams, mock-ups, etc. It can be sawed, drilled or milled with metal or woodworking tools. For production cutting of Die Stock, tungsten carbide tipped tools are preferred to carbon, semi-high-speed or high-speed steel tools.

Standard Presdwood is another all wood-fiber board of medium density with one side a screen surface. Tempered Presdwood is obtained by a special process, in which the board is impregnated with a special tempering liquid and then polymerizing the liquid by baking.

Tempered Presdwood and Standard Presdwood are capable of numerous fabricating operations and are widely used in automobiles, motor boats, furniture, railroad and other transportation equipment, toys, outdoor signs, displays and hundreds of other items. The two types differ in that Tempered Presdwood is harder, denser and higher in modulus of rupture and tensile strength. It also has great resistance to abrasion and water absorption. With its excellent weathering qualities, Tempered Presdwood is used extensively for exterior applications.

Both Tempered and Standard Presdwood have a smooth surface and a "screen side." Normally the smooth surface is exposed, but for some applications the screen side is used. Both types are made in 1/8-, 3/16-, 1/4- and 5/16-in. thicknesses. If greater thicknesses are desired, the boards can be laminated, using various types of adhesives, depending on the type of glue spreading equipment available. In addition to being laminated to themselves to obtain greater thicknesses, hardboards are laminated to high-grade wood veneers; they are used as the inner, or core plies in the manufacture of plywood, and are laminated to sheet plastic materials for use in table and counter tops.

Tempered Duolux is another type that is smooth on both surfaces and is manufactured under a somewhat different process. As a result, it has slightly different physical properties. It is used primarily in the tile board industry and in the manufacture of items requiring smoothness on both surfaces. It is made in thicknesses of 1/8, 3/16 and 1/4 in.

Benelex "70," an exceedingly dense board, is similar in many respects to Die Stock. Because of its electrical insulation qualities, it is useful for such items as switch panels, switch terminal bars, jack bars, etc. An accompanying table lists its electrical properties.

Characteristics and Properties

Hardboards are manufactured in flat sheet form with a basic size of 4 by 12 ft. The standard width is 4 ft., but sheets are available in various standard lengths and thicknesses, depending on the type. Hardboards are brown in color having a smooth mottled appearance, so that in many applications they can be used in their natural state. If other effects are desired, they are receptive to a wide range of finishes, including lacquers, enamels, oil paints, stains, metallic paints, and many other synthetic finishes.

All Masonite hardboards are characterized by the equality of strength in all directions parallel to the surfaces. This is a distinct advantage over ordinary wood, in which a high degree of tensile strength exists only in that dimension which runs parallel with the direction of the grain. These hardboards also possess desirable dielectric properties.

Hardboards being made of wood contribute no noise of their own when used in radios and phonographs and other devices in which resonance control is important. The material does not split, splinter or set up tinny noises, within very broad limitations of product applications. These products are controlled results of industrial procedures rather than materials varied by accidents of nature.

Although manufactured from wood, hardboards have a slower combustion rate because of the removal of the pine oil, turpentine, and other inflammable ingredients. Tests run to determine the resistance to heat, and the maximum temperature permissible for baking on finishes showed that a continuous temperature up to 350 F for 4 hr. had no detrimental effects on hardboards.

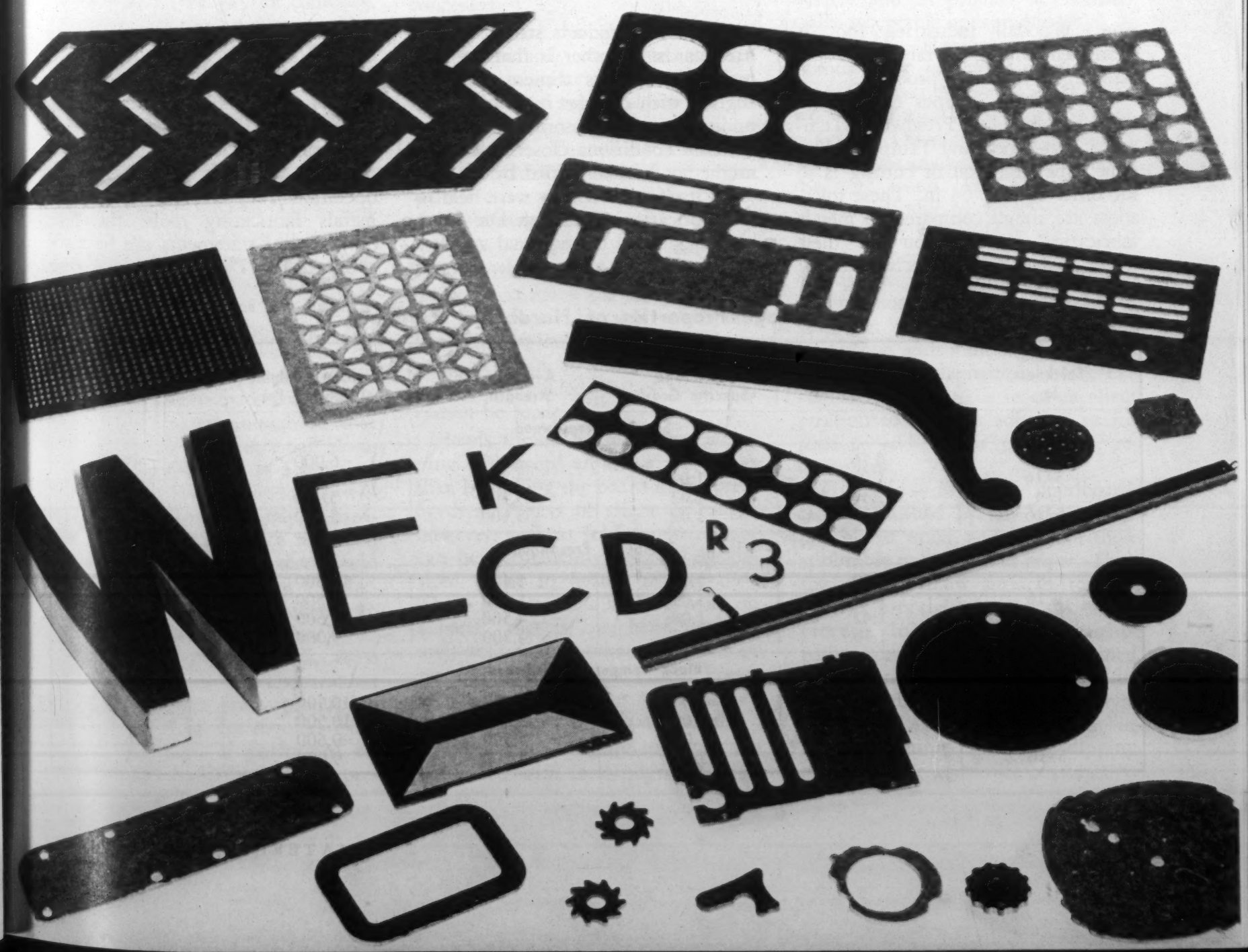
Electrical Properties of Hardboard
(Benelex "70")

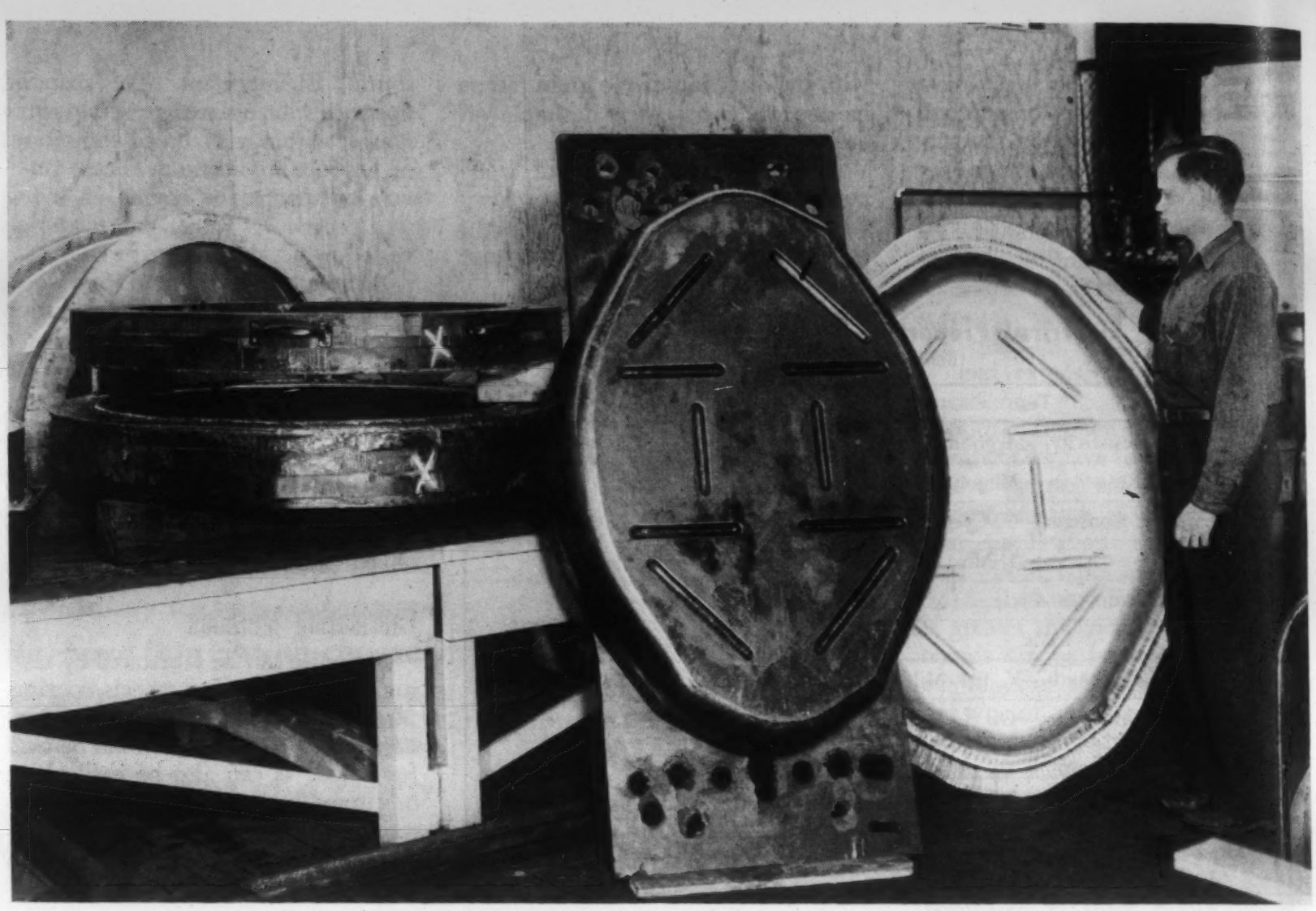
Test	Benelex "70"
Surface Resistivity—Megohms	2.5×10^5
Volume Resistivity—Megohm In.	6.5×10^5
Dielectric Constant—60-Cycle	7.00
1 Mc.	6.00
Power Factor—60-Cycle	0.070
1 Mc.	0.045
Dielectric Strength—V. per Mil	
Short Time Test—Oil (¼-In. Board)	185
Short Time Test—Air (¼-In. Board)	135
Step By Step Test—Oil (¼-In. Board)	140
Step By Step Test—Air (¼-In. Board)	105
Arc Resistance—Sec.	190

Fabricating Methods

Masonite can be fabricated by sawing, drilling, abrasive wheels, routing, planing, nailing, screwing, and adhesive methods such as would be used for wood. It can also be easily bent or curved in one direction. This material lends itself readily to fabrication by a multitude of methods both for small quantity and mass produc-

Intricate shapes such as these can be produced rapidly and economically out of hardboards by die-cutting.





The plug section of a deep draw pressure ring die made of Masonite Die Stock, standing up (left), is used to form a 0.051-in., 18:8 stainless steel part (right).

tion. Woodall Industries, Inc., is prominent among the fabricators specializing in Masonite products.

Die Cutting—Shapes can be die cut out of Standard Presdwood, Tempered Presdwood and Tempered Duolux. The precision of cutting is to the order of $\pm 1/64$ in. These tolerances are rough compared to metals fabrication. One reason for their width is that higher precision rarely is needed in products stamped from hardboards. Another is that the material changes its dimensions very slightly with changes in ambient humidities, so that in some cases under extreme conditions closer tolerances might not be maintained by the material itself even if they were held in the fabrication. Although Die Stock has exceptional dimensional stability and can be held to close tolerances, it cannot be die cut because of its great density, strength and the thicknesses in which it is made (¼ to 2 in.).

Tool costs vary with the type of hardboard and with thickness. These tools vary as widely in costs in accordance with the intricacies of the operations they are to perform as do metals fabricating tools; therefore, only general statements can be made about them. Die cutting tool costs

Average Properties of Hardboard Products

Nominal Thickness, In.	Average Weight, Lbs. per Sq. Ft.	Average Specific Gravity	Average Ten. Strength, Psi.	Average Modulus of Rupture, Psi.	Average Water Absorption, 24 Hr., % by Weight
Standard Presdwood					
1/8	0.76	1.02	3,200	6,000	16
3/16	1.01	1.02	3,200	5,900	13
1/4	1.36	1.02	3,100	5,900	11
5/16	1.72	1.02	3,100	5,800	9
Tempered Presdwood					
1/8	0.79	1.09	5,400	10,500	13
3/16	1.10	1.09	5,000	10,500	7
1/4	1.42	1.08	4,500	9,600	6
5/16	1.76	1.07	4,200	9,000	5
Black Tempered Presdwood					
1/8	0.79	1.09	5,400	10,500	13
3/16	1.10	1.09	5,000	10,500	7
1/4	1.42	1.08	4,500	9,600	6
5/16	1.76	1.07	4,200	9,000	5

Average Properties of Hardboard Die Stock

Thickness, Nominal In.	¼	⅜	½	⅝	¾	1	1¼	1½	2
Weight, Lb. per Sq. Ft.	1.85	2.80	3.80	4.70	5.60	7.60	9.45	11.30	15.00
Specific Gravity	1.38	1.39	1.40	1.41	1.41	1.41	1.41	1.41	1.41
Tension, Psi.	7,700								
Modulus of Rupture (Average), Psi.	12,500	12,500	12,500	12,500	12,500	12,500	12,000	12,000	10,000
Compression, Psi. (Ultimate)	26,500								
Modulus of Elasticity (Average)	1,250,000								
Shear Strength, Psi.	7,100								
Impact Izod	Edgewise 0.6						Flatwise 1.5		
Bond Strength, Psi.	450	480	500	500	500	500	500	500	500
Hardness Rockwell	90 (M Scale)								
Water Absorption %, 24 Hr.	1.2	0.9	0.9	0.8	0.5	0.4	0.4	0.4	0.3

increase rapidly as stock thicknesses become greater than ⅛ in. And these tool costs are, roughly, five times greater for tempered stock than for standard. But the costs are more closely related to the complexities of contours to be cut than to any other factor. A 4-ft. by 4-ft. by ⅛-in. thick piece of simple contours might quite possibly require only inexpensive rule dies while a much smaller piece of involved contours would require higher cost tools.

Die cutting can be used to punch out holes and other interior contours, as well as exterior contours. The complexities of contours are not directly limited by the dimensional tolerances. Slots having widths of less than 1/64 in. (0.0156 in.) can be punched; corners can be square, radii true.

Since the fibers of hardboards are elastic and are of random lengths and strengths, as well as lying in random directions, they do not always shear with complete uniformity at the first die cutting. The edges are slightly rough in appearance, the extent and depth of which depend somewhat on the size of the finished piece.

A second, or shaving cut will make these edges smooth enough so that rubbing the tip of a finger nail along them, as is often done as a practical test of steel surface smoothness, will detect no roughness. Rarely is hardboard used for any service to which a micro-inch smoothness test would be applied. When such a requirement exists, edges can be buffed to an amazing degree of smoothness.

In die-cutting hardboards, mass quantity production, as with other materials, reduces unit production cost. The shaving cut requires extra tooling cost and, if performed on small enough quantities so that progressive dies are not warranted, requires an extra operation.

Edge Treatment—The shapes of edges can be made to true right angles with the broad surface planes, or to true bevels, or to quarter round, half round, or to nearly any other contour which can be generated by cutters of the milling cutter type. This involves an extra operation but results in completely smooth edges. Edge smoothness is usually only necessary when the edges are to be exposed to view. In many assemblies, the edges are concealed.

The cutters for the least costly shaping methods can follow contours of ½-in. radius or greater. Contours having smaller radii and all interior contours can be edge-shaped by the use of routers. The results in smoothness, accuracies and fidelities to contours are just as good, but the operation is somewhat slower.

Bending—Both Standard and Tempered Presdwood can be bent in one direction to much the same contours that metal would be bent on a brake. Bends in ⅛-in. hardboard can have radii as small as 2 in. Compound curves or molded shapes, however, cannot be made.

Bends should be made by "wrapping" the board around a roll rather than by forcing the board into a press or die. Objects of slight curvature, however, such as folding chair seats, can be permanently bent to the desired shape in heated mating dies. There is no trouble with "a bend on a bend," that is, one bend immediately following another with little or no straight area between them. Presdwoods do not work or strain harden to prevent this, as do some metals.

Laminating—Hardboards can be laminated with steel, plywood, lumber, aluminum, plastics and other materials. They serve as one or more surfaces, or as a stiffening core. Some laminations use Presdwood as the stiffening and protective surface over soft, light-weight, highly insulating and noise-deadening cellular materials which in themselves have very slight physical strengths. Presdwood is also laminated with itself to secure increased thicknesses at low costs. Lamination ordinarily must be followed by an edge-trimming operation to remove hardened exudations of adhesives and to produce a commercially acceptable appearance.

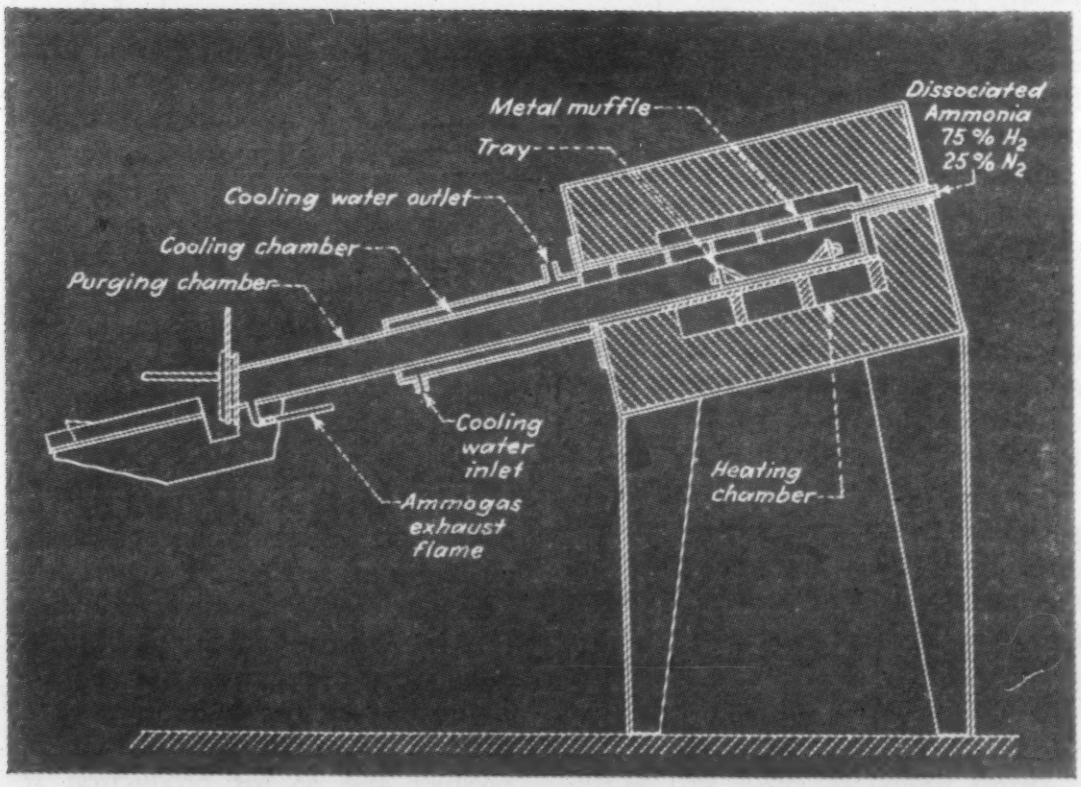
Assembly—Hardboards, though less porous than ordinary woods, have those fibrous constituents which make woods almost ideal for fastening with adhesives. Therefore, they can be used with almost any adhesive suitable for use with wood. Any pressures and cycles applicable to the adhesives and to the other materials to which it is to be joined can be used. Hardboards constitute a group of the easiest and most satisfactory materials to assemble. Some adhesives will hold Presdwood with joint strengths greater than that of the material itself. The engineer, therefore, is in an excellent position to suit his adhesive to his product and to his production requirement.

Finishing—Masonite hardboards can be finished by any method applicable to wood, and many of those applicable to metals and paper. Their smooth and hard surfaces may be printed, especially by the silk screen process. In addition, they can be painted, lacquered, enameled, stained, flocked and varnished, as well as finished by the penetrating sealer type of finish. Application methods include brushing, spraying, dipping, roller coating and knife coating.

Tools and Dies Bright Hardened and Brazed in New One-Step Process

Repair or modification of tools and dies as well as fabrication of new ones is possible with this simultaneous brazing and heat treating technique for air hardening tool steels.

by SAMUEL DAMON & A. L. PRANSES,
Materials Engineering Dept., Westinghouse Electric Corp.



Sectional view of the Ammogas furnace showing the two-chamber arrangement.

● IN THE PAST furnace brazing has not been widely applied to tools and dies, primarily because the atmosphere requirements for tool steels have been largely unattainable in ordinary furnace equipment. Some furnace brazing of tool steels has been done where the content of easily oxidizable constituents, such as chromium, silicon, manganese, etc., was low enough to assure oxide-free surfaces. And the more highly alloyed steels can be brazed satisfactorily through the application of a flux to provide the oxide-free surfaces necessary for successful brazing. However, it is often necessary to allow grinding stock on the assemblies to enable the removal of surfaces decarburized during the brazing cycle.

Development of the "Ammogas" furnace originally designed to bright heat treat tool steels now makes possible the simultaneous brazing and bright hardening of these steels. The furnace is of the batch type, with both a heating chamber and a cooling chamber containing a protective atmosphere. Because of its unique design, the purity of the protective atmosphere can be preserved; an atmosphere of dissociated ammonia with a moisture content in the neighborhood of 0.01% (−40 F dew point) can be maintained within the hot zone and cooling chamber. Satisfactory work may perhaps be possible without these refinements, but brazing fluxes are then required and the resulting work is not bright.

How Process Works

With this process a tool steel assembly to be heat treated is given the same heat treating cycle in the furnace, just as if brazing were not being conducted. The brazing alloy is in wire or sheet form, and is simply placed in the immediate proximity of the joint to be brazed. If the joint has been properly prepared, as described later in this article, the molten brazing alloy will remain in the joint indefinitely due to the capillary forces. Thus, the steel may be held at the austenitizing temperature for the proper soaking time. The steel, if of the air hardening type considered in this article, is quenched in the atmosphere protected cooling chamber,

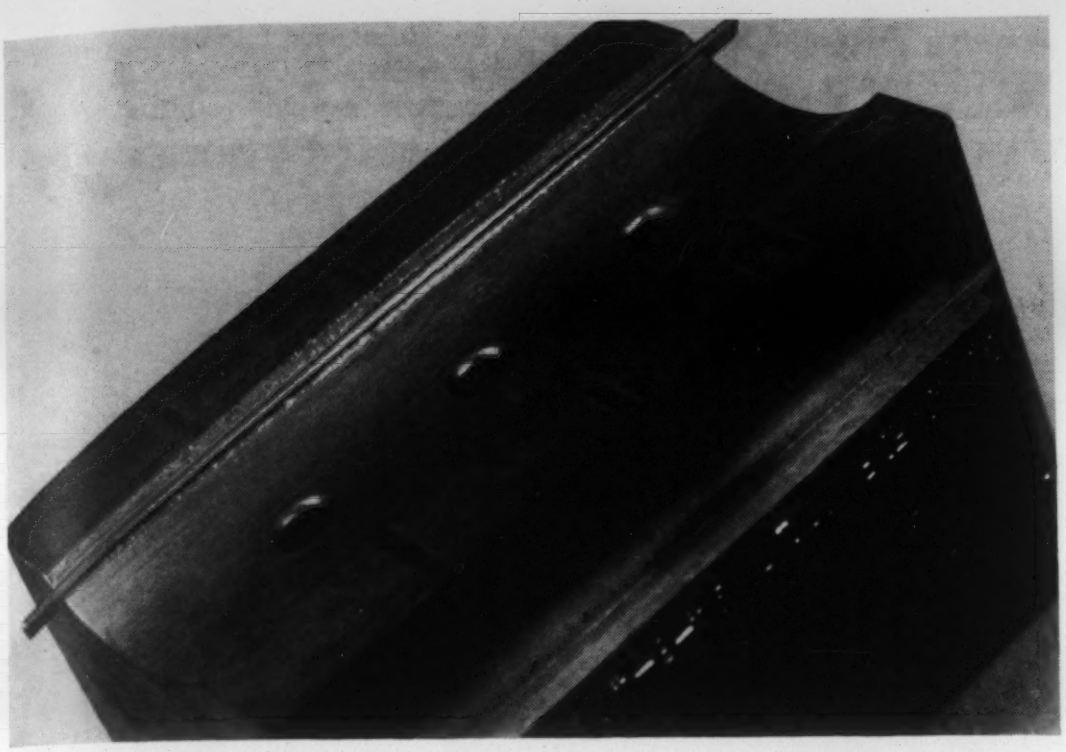


Fig. 1—Bottom die for plastic handle mold showing steel ridge brazed into upper surface.

then tempered in the normal manner.

A typical sound braze obtained in this manner using a 1 carbon, 5 chromium, 1% molybdenum tool steel as the parent metal is shown in an accompanying illustration. The soundness of the braze and the fully hardened martensitic structure of the parent metal are apparent. Considerable diffusion between braze metal and parent metal is visible in this case, greatly strengthening the brazed joint. The two members of this assembly were originally a snug fit, but the braze metal has penetrated through the joint easily and retains a finite thickness of about 0.0015 in. This amply demonstrates the ability of the alloy to flow into confined joints. Even when two members of an assembly are press-fitted together with interference between the components, the braze metal will flow between the small spaces provided by microscopic surface irregularities in the joint.

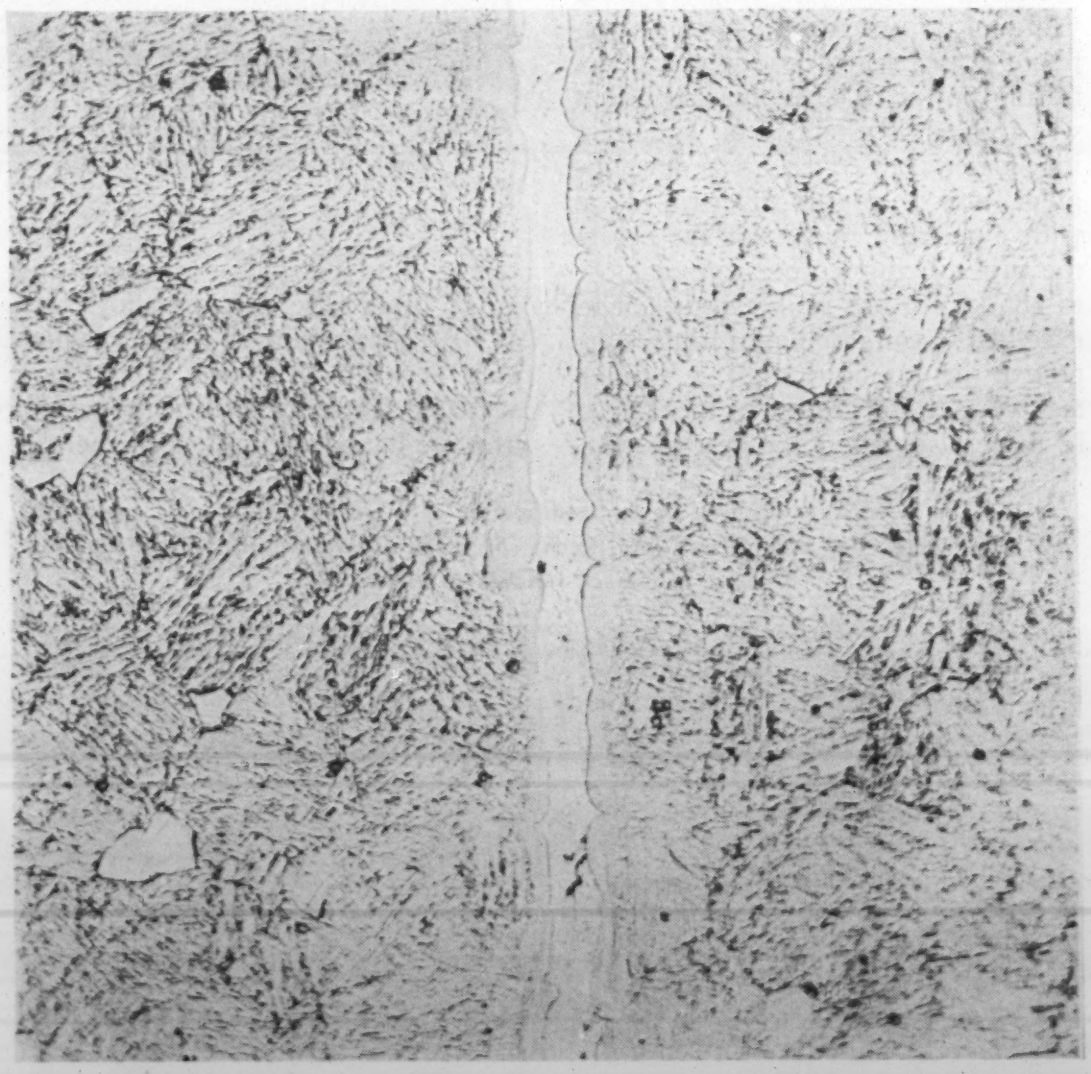
For successful brazing the tool steel assemblies must be properly prepared. Surfaces in and about the joint must be clean, free from foreign particles, oil and grease. A slightly rough surface is preferred within the joint to abet wetting and distribution of the brazing alloy throughout the joint. Of course, when close tolerance fits are required, as they would be in most tool applications, ground surfaces are required, but these can ordinarily be brazed successfully if all other precautions are observed. In instances where it is possible, a medium machined surface—intermediate between rough and finish machined—should be provided.

When putting assemblies through the furnace to be brazed, the relationship of the parts must be maintained from start to finish. Several typical ways this can be done are: (1) The simple hole and pin type of assembly should be a press fit allowing about 0.001 in. per in. interference on the diameter. (2) The force of gravity can be utilized. Since some movement may be expected during brazing, extra stock to be ground off after brazing must be allowed if this method is used. (3) Parts can be swaged or peened together. (4) Parts can be riveted or tack-welded together. (5) A common method, and one which will find the widest use when preparing tool assemblies, is that of holding parts together with screws or press-fit dowels.

Brazing Alloys

Because previously copper had been used as the filler metal in furnace brazing of tools, this was the brazing material first employed in treatments carried out in the Ammogas furnace. Although copper gave excellent joints with even such tool steels as the high carbon-high chromium types, its melting temperature, 1981 F, is considerably higher than the optimum heat treating (austenitizing) temperature for most tool steels. Hence, a double treatment was required. This involved heating to a point above the fusion temperature of copper to accomplish the braze, cooling, then reheating and quenching per the normal heat treating cycle for the tool steel involved. A double treatment of this type minimizes grain growth and

Photomicrograph of a typical joint bright hardened and brazed at the same time. (500X)



austenite retention, and therefore is preferred to one wherein the metal is cooled only to the usual hardening temperature after brazing, then quenched. However, the double treatment is undesirable, both from the standpoint of time consumption and the increased risk of distortion to the tool components.

Silver brazing alloys had long been considered unsatisfactory for use as the filler metal in tool steel assemblies, because of the lower strength displayed by such joints. The use of flux was previously considered compulsory, and clearances of 0.002 in. and greater were generally employed with such alloys due to the lower fluidity and penetrating power they displayed. It was felt that some improvement might result if these conditions were improved, *i.e.*, the fits made interference or at least zero clearance and fluidity increased, since it is well known that maximum strength in brazed joints develops from minimum clearance if complete wetting is attained.

Since the furnace had been successfully applied to the simultaneous bright hardening and fluxless silver brazing of the 13% chromium, hardenable grades of stainless steel, even though press fits were employed, the value of an extremely pure atmosphere in increasing fluidity and penetrating power of silver brazing alloys was apparently established. The brazing material used in that development was a copper-silver-tin alloy with a melting range not far below the austenitizing temperature of 1795 to 1850 F for this stainless steel. The excellent results achieved thus suggested the application of a similar technique to the joining of tool steels. In those cases where the heat treating temperature demands a lower melting range, other silver brazing alloys such as 50% copper and 50% silver, which melt between 1435 and 1580 F, are available. Thus, for each of the widely used air hardening tool steels there is available a silver brazing alloy with a melting point or range lower than the austenitizing temperature of the steel, but by not too great a margin.

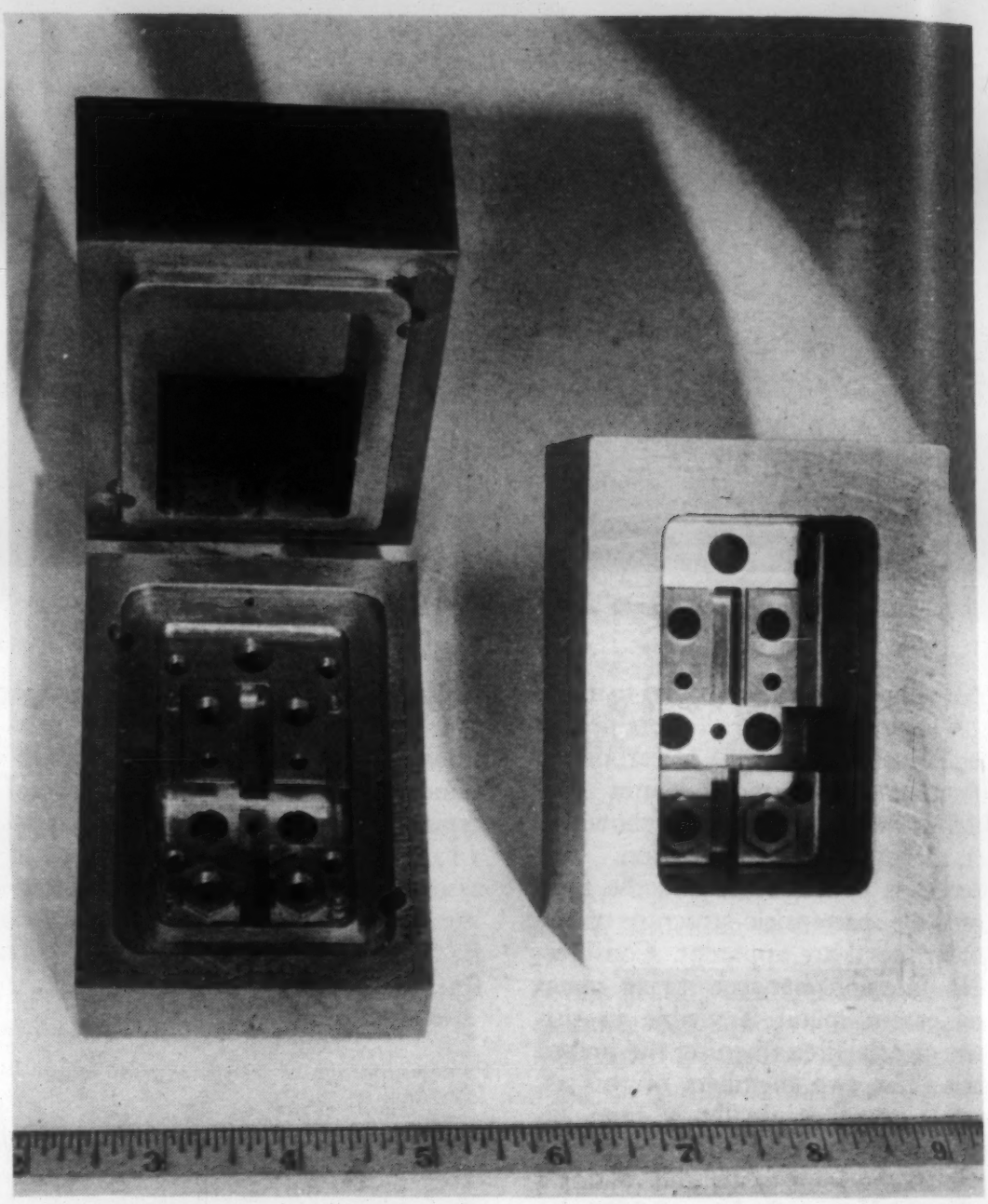
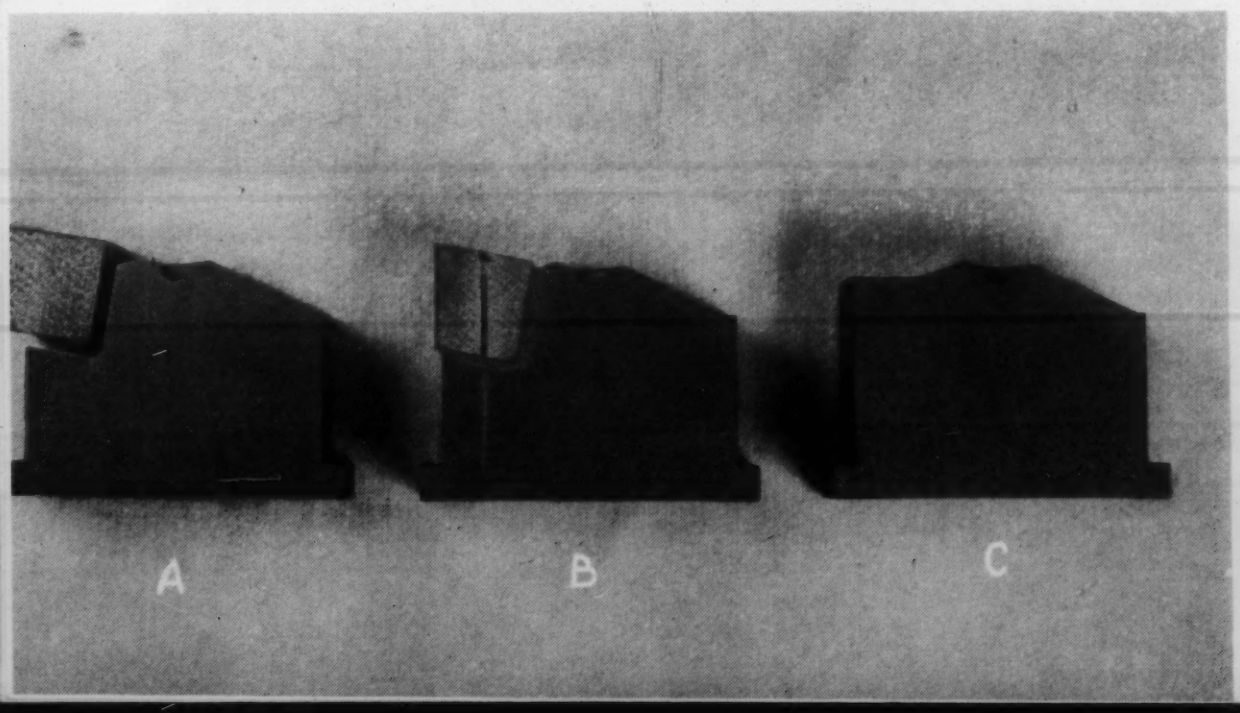


Fig. 2—Two-piece construction of brazed bottom die of a plastics mold is shown at left. Right, appearance after simultaneous brazing and heat treating operation.

Fig. 3—The three steps involved in the modification of a plastic handle mold component are shown here. (A) Block fitted into notch; (B) Block simultaneously brazed and heat treated; (C) Block finished to dimensions.



The strength (almost always expressed as shear strength) of a brazed joint depends on many factors, such as surface cleanliness and condition of parent metal, tightness of the joints, time at heat, furnace temperature, subsequent heat treatment, etc. In general, a sound braze using copper in a press-fit joint with about 0.001 in. per in. interference can be expected to have a shear strength approaching 30,000 psi. if clean surfaces and optimum brazing conditions exist. Although this value is low compared to the shear strength of hardened tool steels, proper design can almost always minimize the need for strength in the brazed joint itself.

A test was conducted to compare the strength of a copper brazed assembly, which was subsequently heat treated, with a similar assembly simul-

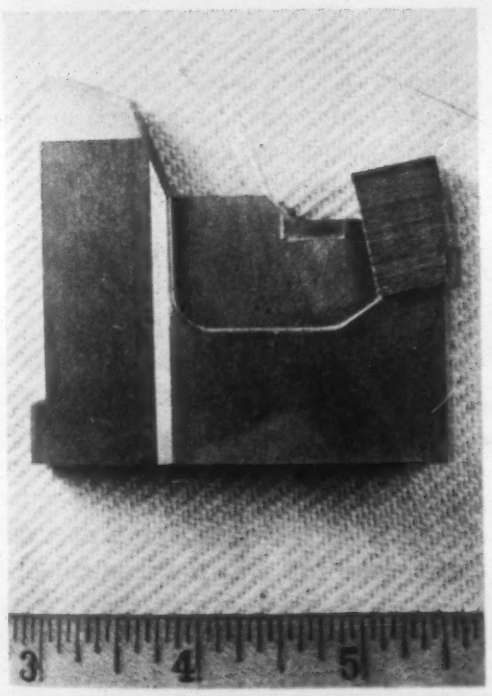
taneously brazed and heat treated using the 50 copper, 50% silver material. By recording the load required to push a pin that was brazed into the test samples it was possible to compute shear strength in lb. per psi. Each sample was brazed and tested three times, thus giving 12 values for each brazing process. The data so obtained failed to show a size effect within the range of sizes tested. The strength data obtained are listed below.

The above data indicate that the simultaneous brazing and heat treating operation produced joints of equal strength with those brazed with copper and subsequently heat treated (double treatment).

Practical Applications

This simultaneous brazing and heat treating technique has already had a number of successful applications,

Fig. 4—A block (upper right) was brazed into place on this mold, then tempered to a machinable hardness and finished.



and below are given brief case histories of a few of them.

Bottom Die for a Plastic Handle Mold—Fig. 1 shows the die immediately after the simultaneous brazing and heat treating operation. The original design for this die called for the small ridge, shown running lengthwise along top, to be machined as a part of the die proper. By providing for brazing a tool steel strip of proper size which fits into the die as shown, use of a simple milling cutter was made possible. The original design would have required costly profiling on the vertical type (Gorton) milling machine and considerable hand finishing. The die and strip were both made of modified SAE 3335.

Sheet Metal Punching Die—These punches were made from air hardening high carbon, high chromium tool steel. Brazing in this case permitted use of a lathe and slot cutter instead of requiring costly profiling. Performance of these punches has been excellent.

Blanking Die—A blanking die made from the 1 carbon, 5 chromium, 1% molybdenum die steel was hardened at the same time that it was brazed to a medium carbon back-up plate; this eliminated the need for complicated mechanical fastening, and performance was satisfactory.

Bottom Die, Plastics Mold—Fig. 2 shows the mold component, made from modified SAE 3335, before and after brazing. Screws were used to hold the components together during brazing and simple drilled wells were used to introduce the brazing alloy to the joint. Resorting to brazing in this case greatly reduced the cost which would have resulted from machining complex shapes in the bottom of a deep cavity.

Bottom Die of Transfer Mold—These dies were simultaneously hardened and brazed to repair worn portions by applying tungsten carbide inserts at the points of highest wear. The dies, made of modified SAE 3335, were annealed, slots were profiled at worn points, and tungsten carbide inserts were brazed into place at the same time as the dies were rehardened to 56 Rockwell C.

Permanent Mold Component—A thin projection was badly worn in this permanent mold component made of the 0.35 carbon, 5 chromium, 1% molybdenum type hot work steel. The worn portion was ground out, and a replacement part was tack-welded to hold it in place during the brazing heat treating operation. The part has proved serviceable since the mold is used for casting alloys with a melting point far below that of the brazing alloy.

Plastic Handle Mold Component—This case illustrates the application of simultaneous brazing and heat treating to modification of a mold component. Fig. 3 shows the three steps involved: (A) Slot ground out and a rough block prepared with only the contact surfaces fitted. (B) After brazing and heat treatment. (C) After finishing. Three points are significant in this case: first, it was not necessary to anneal the pieces to achieve the modification since the required slot could be ground; second, the brazed joint is virtually imperceptible; and third, the block which was brazed into place was originally in the annealed condition while the die was hard. After the simultaneous brazing and heat treating operation, both parts were at a hardness of 55 Rockwell C. This modified die component has given satisfactory service for about eight months.

Plastics Mold Insert—In this case, the machinist failed to leave adequate stock for the small boss on the right of the mold. A block of steel (modified SAE 3335) was furnace brazed in the desired place as shown in Fig. 4, then the whole assembly was tempered to a machinable hardness and finished.

From the examples just given it is evident that the simultaneous brazing and heat treating technique can be far more widely applied to the repair and modification of existing tools and dies than it has been in the past. Broken projections can be repaired by providing a replacement in the form of a brazed-in insert. Worn or indented areas can be repaired by brazing either tungsten carbide or tool steel wear plates into the die. Machining errors on costly tool parts involving the removal of too much stock can often be rectified by brazing in a block to replace the stock removed by mistake. Stress concentration points (shoulders, sharp corners, etc.) which are essential to the design, and which often lead to subsequent fracture, can be reduced by making such components in two parts brazed together.

The broadest potentialities of this process lie in its application to those parts which, by virtue of their complexity, involve much costly, complicated machining and hand finishing. By making such parts in several pieces to be subsequently brazed together, machining and hand-finishing can often be greatly facilitated.

	Average Shear Strength, Psi.	Standard Deviation, Psi.
Copper braze, then heat treat	29,400	3800
Simultaneous silver solder braze and heat treat	30,330	4320

Base Metal Selection Important to Successful Porcelain Enameling

The four classes of ferrous sheet commonly used for porcelain enameling are discussed in respect to their drawing and enameling properties and their resistance to sagging and warping.

by **FRANK R. PORTER**, Ceramic Engineer, Inland Steel Co.

● TODAY THE MAJOR proportion of porcelain enameled parts are fabricated from steel or iron sheets, and the type, chemical composition and quality of the sheets determine in large measure the success of the enameling operation. As is well known, porcelain enameling consists of fusing glasses of special composition to a metal base. The majority of enamels today require temperatures of from 1500 to 1600 F for this fusing process. To be satisfactory, the glass coating must not only be continuous and defect free, but must adhere tenaciously to the metal base.

The theory of adherence to which we subscribe is that during the fusing process an interfacial layer of iron oxide (FeO) is formed, which dissolves in both the glass and the metal base, thus bonding the glass to the base metal much as zinc is bonded to steel in the galvanizing process. During the fusing process, gases are evolved from the metal base, from moisture chemically combined with certain of the glass ingredients and from chemical reactions between constituents of the steel and glass. The composition and quality of these gases are important to the success of the enameling operation.

For example, from a small pearlitic area in the surface of the metal can be evolved a sufficient volume of gas to cause a reddish brown defect in the enamel finish over the area, known as a "copper head." It is an over-oxidized area, and chemical analysis shows it to be composed largely of iron oxide. The flow of gas or gases has been sufficiently violent during the fusing cycle to force the fluid glass away from the metal and permit the oxidized area to form. On the other hand, the evolution of gas from the base metal may be less violent, but sufficiently violent and prolonged to cause blisters in the enamel finish. This is referred to as "boiling." Still another example, to indicate the rigid requirements for a satisfactory sheet for enameling, is the rather close limits of the percentage of manganese required in sheets for certain specific applications.

There are three main qualities desired in sheets for porcelain enameling: suitable drawing qualities to make the part intended, good enameling properties, and high resistance to warping and sagging at enameling temperatures. No commercial product has these combined properties to the fullest extent, but steel producers through research and development work are approaching the solution to the production of an ideal sheet.

Research conducted by the steel mills has resulted in the development of superior products for the enameling industry, and today four classes of sheets are in use: (1) mild steel, (2) enameling iron, (3) titanium enameling steel, and (4) mild steel coated with substantially pure nickel to a thickness of approximately 0.000015 in. All are basic open hearth products, and each class of sheet normally has definite applications, but today they may be used interchangeably due to the high demand for sheets for enameling purposes. Some of the important properties of these will be discussed in the following paragraphs.

Mild Steel

Under the mild steel classification falls tin mill black plate, used largely for hollow-ware; cold rolled sheets used for hollow-ware and stove equipment for particular applications; and hot rolled annealed pickled sheets for applications similar to those for cold rolled sheets. It is customary to specify these sheets dry, *i.e.*, free from the oil used by the mill for protection against corrosion during transit and storage. Some of these oils are difficult to remove in the enameling shop.

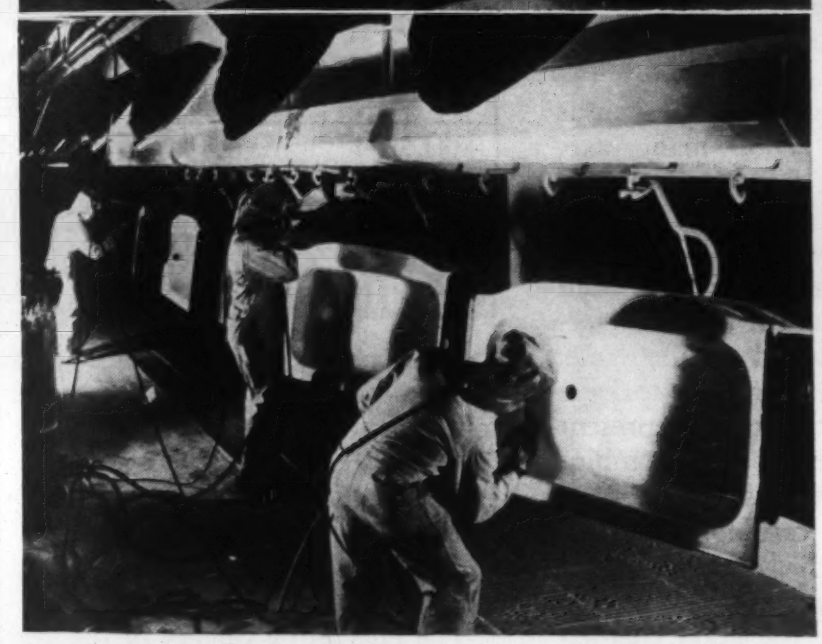
Hot rolled annealed sheets, while coming within this classification, are not used for enameling purposes because the loosely-adhering, partially reduced oxide on the surface of the sheet is not removed by the normal cleaning and pickling process and will cause difficulty in enameling.

Mild steel sheets correspond to AISI C-1009 in chemical composition, a typical ladle analysis being: 0.08 carbon, 0.35 manganese, 0.015 phosphorus, 0.030% sulfur, and a trace of silicon. These sheets are normally used for parts in which warpage or sagging at enameling temperatures can be tolerated, or where the design is such that warping does not occur, and for which the quality of the enamel finish is not the highest. Drawing quality of these sheets is excellent or can be so made when that quality is desired. In fact, the chemical composition of this type is comparable with that of sheets often furnished the automotive trade for deep stampings; it follows, therefore, that the same excellent stamping quality can be obtained by correct mill processing.

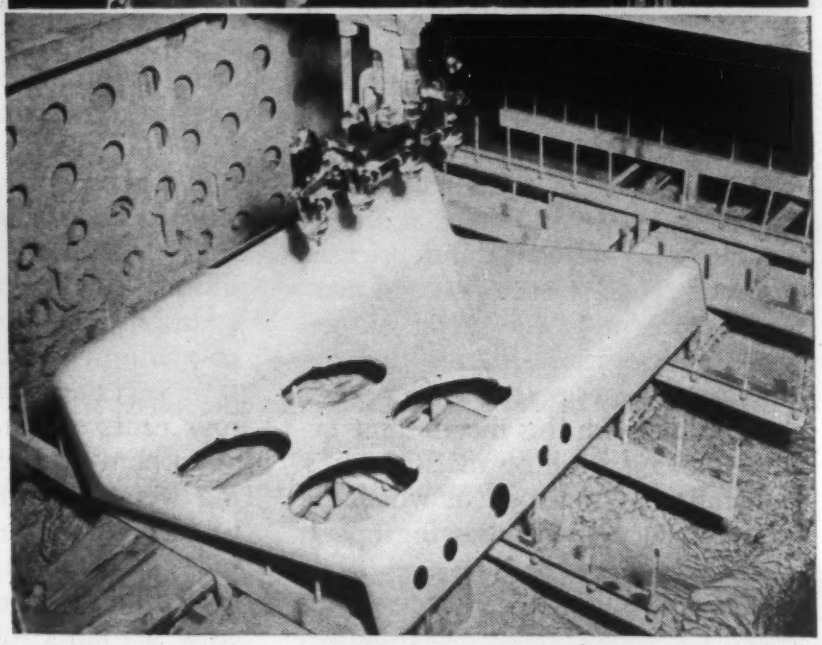
The enameling quality of mild steel is inferior to that of the other three types. The relatively high carbon content is mainly responsible for this difference, although manganese adversely affects enameling quality, too. The carbon is present as iron carbide, which is highly reactive with iron oxide, hydrogen, etc., at enameling temperatures. One of the reaction products is a gaseous carbon

Steel for porcelain enameling must have good forming properties. (Photo: Courtesy Erie Enameling Co.)

Welding a section of an outdoor sign before porcelain enameling. Welds should be of same composition as enameling stock.



Spraying steel bathtubs with porcelain enamel. Later they will be fired in a continuous furnace at 1550 F.



One of the prime requirements of enameling steel is that it have good enameling properties.

compound which, if evolved in sufficient quantity, may result in a defective coating with regard to both appearance and adherence. Hydrogen is undoubtedly one of the most undesirable elements with which the enameler has to contend, and its origins are many. Steel making, steel mill processing, enamel shop cleaning and pickling, and chemically combined water in the enamel bisque, are a few of the more common sources.

Another source of defects in enamels applied to mild steel is subcutaneous blowholes, which are more or less prevalent in the product from the lower half of the ingot. The discussion applies, of course, to rimming steel only, as killed steel is used to a very limited extent for enameling purposes. These blowholes are far more numerous in mild steel than in enameling iron, because of the higher carbon content of mild steel.

The resistance of mild steel to sagging and warping at enameling temperatures is comparatively low. This is because enameling temperatures are above the transformation or critical temperatures for this metal, and, as is generally known, there is not only a decided lowering of tensile strength but also a rather abrupt expansion on heating and a contraction on cooling at these critical temperatures. Mild steel has three of these critical points, and all are below or in the enameling temperature range for maturing standard enamels.

In passing, attention should be directed to work being carried on by frit producers with "low temperature" enamels. These are for application mainly to mild steel, and the temperature required (1300 F) for maturing or fusing them to the base metal is below the thermal critical points of steel, so that little or no warping occurs. A prefabricated steel house soon to appear on the market will be finished with these low temperature enamels applied to mild steel.

Enameling Iron

Prior to 1914, sheets available to the enameling industry were of the mild steel classification. At about that time the American Rolling Mill Co. began the production of Armco ingot iron for this industry, and the chemical analysis of this product approached that of pure iron. The product, as now made by most of the principal steel producers for the enameling industry, is universally known as enameling iron although marketed under various trade names. A typical

analysis is: 0.03 carbon, 0.04 manganese, 0.010 phosphorus, 0.030% sulfur, and a trace of silicon.

Enameling iron is a premium product compared to mild steel because of the higher cost of production. Enameling iron has a "red short" or critical working temperature range, within which the metal is brittle and practically non-workable. This red short range is caused by the low manganese to sulfur ratio in the metal. A minimum ratio of about seven to one is required for eliminating this critical hot working range and, as can be seen by reference to the analysis shown, the ratio is approximately one to one for enameling iron. It would be highly advantageous to the steel producer to have sufficient manganese present to eliminate this range. However, enameling and sag resisting properties decrease with increase in manganese.

The drawing quality of enameling iron is good, but not as good as that of mild steel. Its yield and tensile strength are lower in the heat treated condition, as is also its ductility as measured by the Olsen and Ericksen cup tests. The lower carbon and manganese content of the metal account for the somewhat inferior drawing quality. However, very severe draws are possible with this metal, some examples being washing machine tubs, bath tubs and sinks, all of which are produced in a single drawing operation.

The enameling properties of this metal are good, and definitely superior to those of mild steel. This is due to lower percentages of carbon and manganese present in the metal, and to greater freedom from subcutaneous blowholes referred to previously.

The resistance to sagging and warping of enameling iron is good and definitely superior to that of mild steel. This also is due to relatively low percentages of carbon and manganese, with the result that metal of this analysis has but one thermal transformation point—approximately 1600 F—and this is above enameling temperatures. Therefore, parts fabricated from enameling iron tend to be much truer to shape than similar parts fabricated from mild steel.

Titanium Enameling Steel

The application of white enamel directly to the base metal has been the subject of research for many, many years. Many white ground coats have been developed but have seen little or no commercial applications mainly because of the unsatisfactory base metal. Such a finish is highly desirable because enamel shop costs would thereby be reduced and a more satisfactory product would result because of the thinner enamel coating.

During World War II the supply of cobalt oxide for ground coats was limited, as was manpower. A sheet of this type was therefore highly desirable at that time. Several steel companies, frit manufacturers, and other suppliers to the enameling industry have worked, and are continuing to work on the problem. One development has been titanium enameling steel, which has been marketed now for approximately two years in limited quantities. Some users are applying cover coat directly to the metal, and with most encouraging results.

Titanium enameling steel is a basic open-hearth product containing sufficient titanium to combine with the carbon and having a typical analysis of: 0.06 carbon, 0.030 manganese, 0.010 phosphorus, 0.030 sulfur, 0.10 silicon, and 0.30% titanium. It is fully deoxidized with aluminum additions just prior to the titanium addition. The titanium (as 40% ferro-titanium) is added to the ladle. It is necessary, theoretically, to have four times as much titanium present as carbon—the ratio of the combining weights of titanium and carbon to form titanium carbide. This carbide is comparatively stable under enameling conditions, which apparently accounts for the good enameling properties of this metal.

The drawing quality of this metal is good, being superior to that of enameling iron, but somewhat inferior to that of the best deep drawing mild steel. This metal has no definite yield point, but its yield strength measured at 0.5% offset is comparable to that of enameling iron.

There are several very interesting enameling properties of this metal. As stated above, white cover coat enamels can and are being applied directly to the metal with good success. Titanium oxide enamels work well in a single coat and produce a finish having satisfactory reflectance at an enamel thickness of 0.0035 to 0.004 in. This approaches the thickness of a good paint finish. Also, the metal does not reboil, which is of importance particularly for parts that require a transfer or decalcomania fire.

Another interesting property of the metal is its unique coefficient of expansion, particularly at enameling temperatures. This property is measurable for titanium enameling steel in the temperature range of 1400 to 1600 F, while the same property cannot be measured in this temperature range for enameling iron or mild steel, because the change in expansion is too rapid. It is the belief that this property explains the good resistance to warping and hairlining in parts fabricated from titanium enameling steel. This property, no doubt, also explains why stove or range main tops can be produced in white with little or no enamel crazing or chipping from thermal shock in use.

The high resistance to sagging at enameling temperatures is also important. The transformation temperature for this metal is well above 1700 F, or about 100 F higher than that for enameling iron. A comparison of sag resistance properties of the three metals for 20-gage stock when tested under standard conditions is:

	Sag in In.
Mild Steel	0.80
Enameling Iron	0.40
Titanium Enameling Steel	0.15

Coated Mild Steel

This product has recently been marketed by one of the larger steel mills. It is being used largely for parts finished with low temperature enamels—those maturing at approximately 1300 F. The coating is principally nickel and is approximately 0.000015 in. thick.

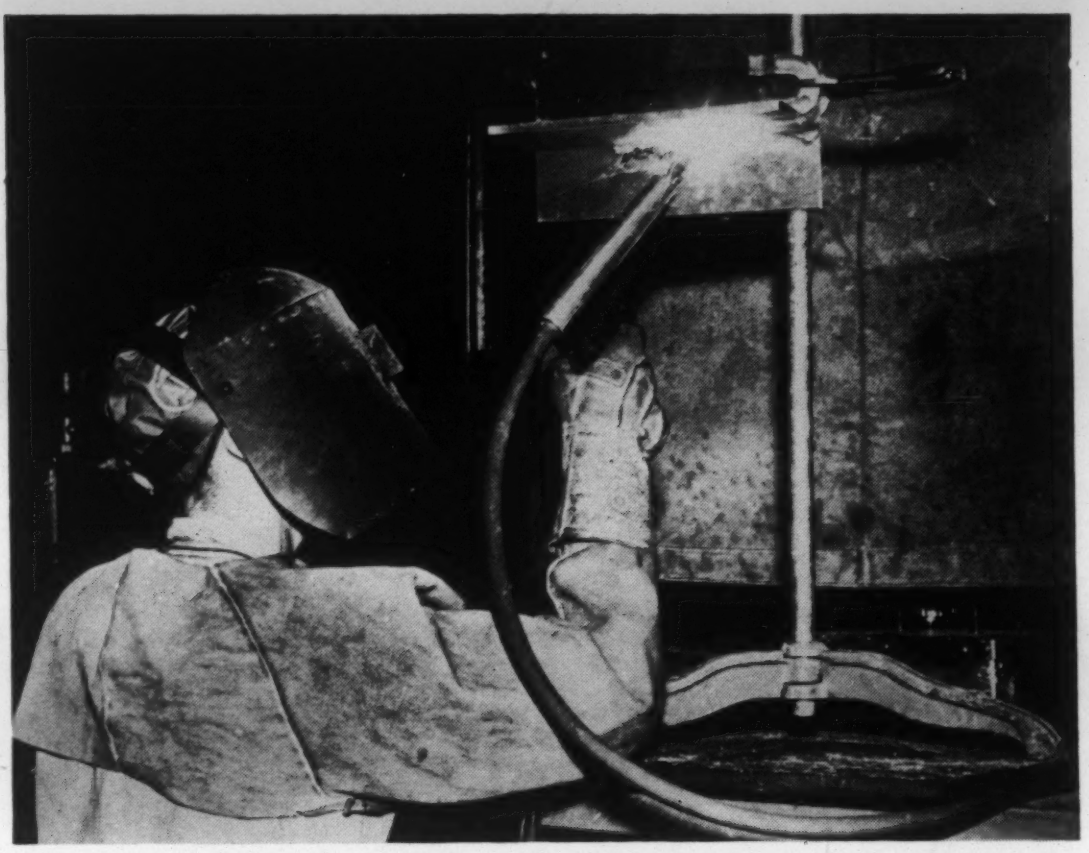
The enameling quality of the steel is good because nickel prevents, in large measure, the flow of gases from the base metal and also chemical reactions of constituents of the enamel with those of the base metal. The resistance to sagging is poor under standard test conditions at 1600 F, but good at 1300 F, the maturing temperature for the low temperature enamels. The drawing quality of this product is good, but there are some limitations, which are determined by the ductility of the coating.

The quality of porcelain enameled products has been greatly improved, particularly in recent years, by the combined research and cooperative efforts of all concerned, but there remains much to be learned about this versatile finish. We know, for example, little about such fundamental things as enamel adherence and chemical reactions that take place during the enamel firing process. However, research is gradually shedding light on such fundamentals, and the industry can view the future with a great deal of optimism.

A NEW PROCESS PREVIEW

Joining Heavy Aluminum Sections Simplified by Gas-Shielded Arc Welding

Conventional non-consumable electrode replaced by continuously-fed consumable wire for gas-shielded arc welding of heavy sections of aluminum and aluminum alloys.



Overhead welding of heavy-section aluminum with Aircomatic gun. Note unencumbered ease of manipulation and visible arc. (Photo: Courtesy Air Reduction Sales Co.)

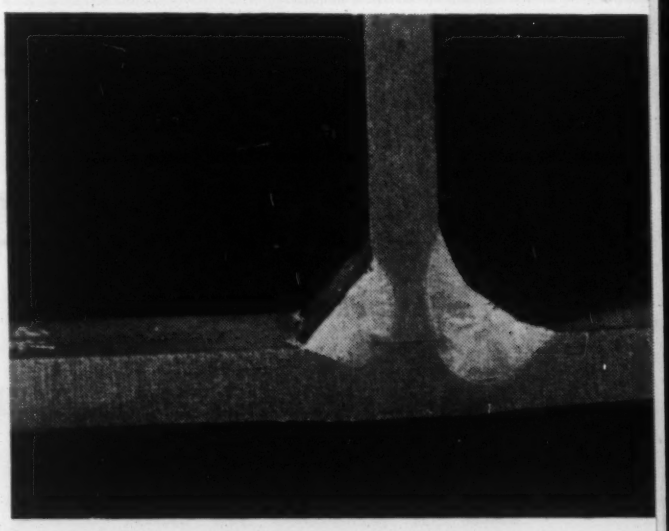
• QUALITY WELDING of heavy-section aluminum and aluminum alloys has long been a problem of industry. But continued advances in inert gas-shielded arc welding techniques have gradually overcome the difficulties inherent in fabrication of this type. Outstanding among the advances made is the "Aircomatic" process, recently developed by the Air Reduction Sales Co. In this, heavy sections of aluminum and aluminum alloys are arc-welded by a continuously-fed, consumable wire at wire feed speeds that range from 100 to 300 in. per min. The consumable wire, fed through the barrel of the manual welding gun, replaces the non-consumable tungsten electrode conventionally used. Power is supplied from a standard d.c. welding generator and the arc is maintained between the end of the wire and the work.

With the Aircomatic unit, welding of aluminum can be performed in all positions. Standard joint designs can be satisfactorily welded with the facility that is customary with metal arc welding of steel. In addition, however, the new process has the advantage of high deposition rate. This results in continuous filler metal feed and the absence of slag. No flux is required and little or no edge preparation or preheat is needed. The arc is always visible, thus eliminating the uncertainties incurred in blind welding. The application of this process to metals other than aluminum and aluminum alloys is now under development, but a combination of factors including current density, gas shielding, and filler wire feed speeds must still be determined before universal application of this process is possible.

For aluminum welding, as currently provided in this process, only three sizes of filler metal are needed: 3/64 in., 1/16 in., and 3/32 in. With these sizes, the overall current range is from 70 to 450 amp. This permits welding of metal thicknesses from ⅛ in. up to 2 in. and more. At the present time, only three types of wire are used.

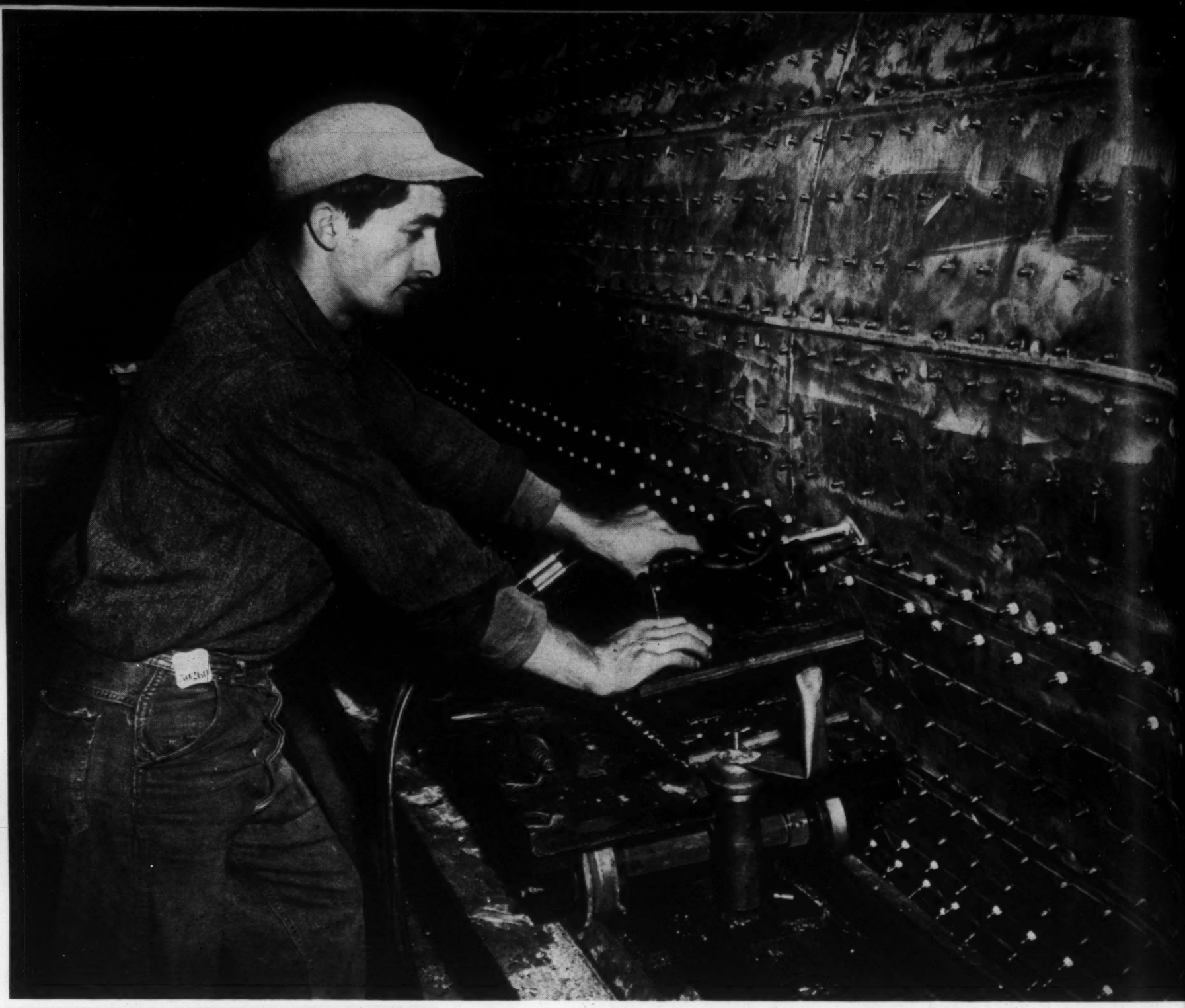
The component parts of the new unit are: The welding "gun"; gas (argon) hose, concentric with which is the metallic tube for conveying the welding wire; a three-conductor control cable; feed motor box; control box; and wire reel.

The welding "gun," closely resembling an automatic pistol in size and feel, is equipped with a trigger which readies the unit for welding and a button for feeding wire when not welding. To start welding, the trigger is depressed. It can be locked in the "on" position. Depressing the trigger starts the flow of the shielding gas. The electrode, protruding about ¾ in. from the gas nozzle, is scratched on the work to produce the arc. Controls to energize the feed motor and deliver filler metal operate when the arc voltage is established.



Fillet welds made on 3/16-in. 61ST aluminum plate by Aircomatic process. Weld on left was made in horizontal position at welding speed of 34 in. per min. Weld on right made in flat position at speed of 30 in. per min. (Photo: Courtesy Air Reduction Sales Co.)

In welding, the gun is held so that it points ahead in the direction of welding. To terminate a weld when no welding current contactor is used, the arc is broken with a quick snap. If a contactor is used in the circuit, the operator need only release the locked trigger.



Studwelding is useful when large quantities of studs must be attached, such as on this petroleum processing unit.

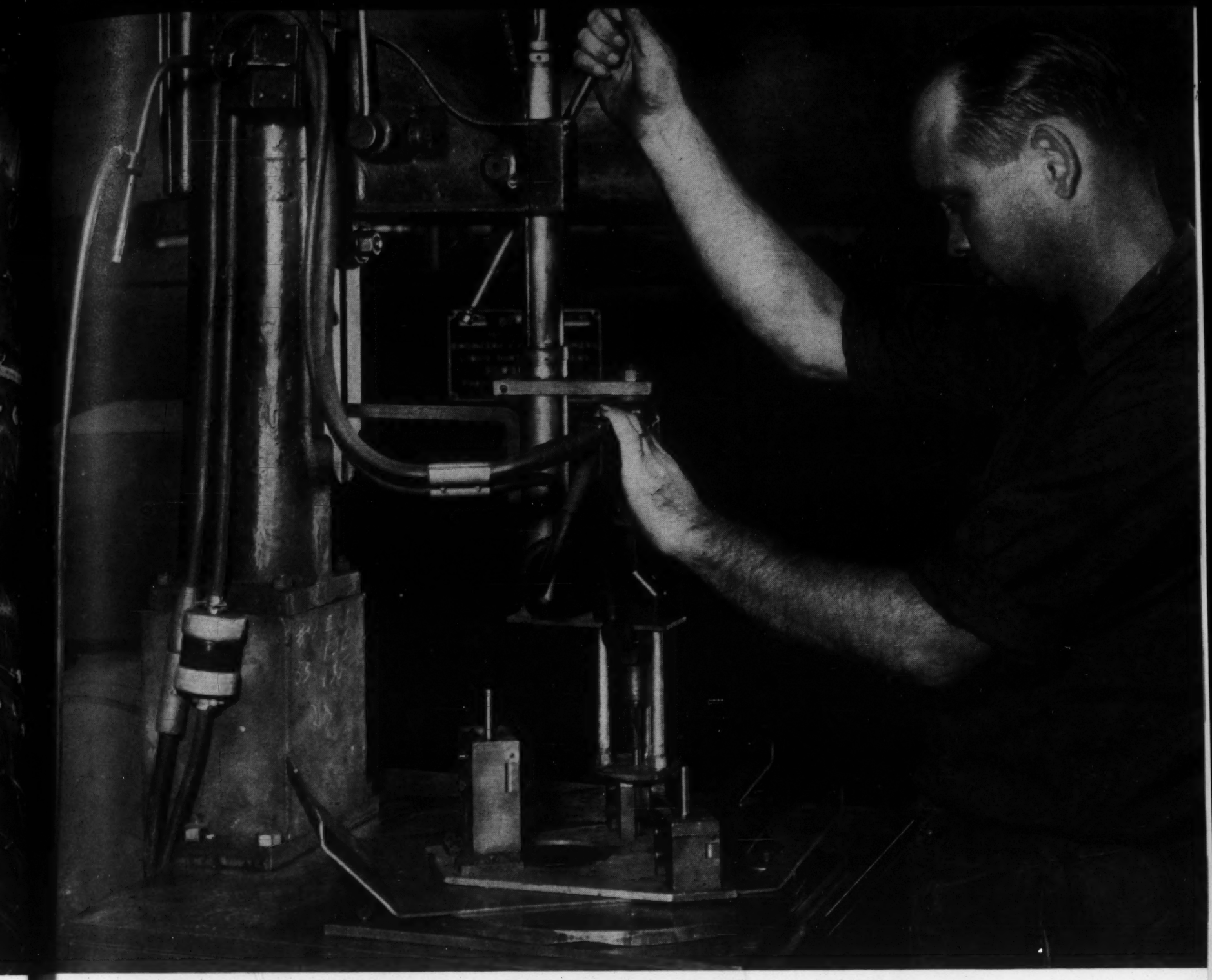
Studwelding—A Versatile Metal Fastening Process

by **ROBERT C. SINGLETON, Manager of Engineering Service, Nelson Stud Welding Div.**

The troublesome problem of attaching studs can be frequently solved with this studwelding process which eliminates drilling and tapping operations.

• A METHOD OF fastening that is applicable to steel and stainless steel in combination with a variety of materials, and that combines the speed of machine production with the strength and rigidity of welding, is making rapid advances in widely diverse fields of industry. It is the process of semiautomatic studwelding, by means of which a fastener, usually threaded, can be applied to a metallic surface without drilling and tapping a hole for it. A simple electric "gun" is used to fuse the specially prepared stud to the metallic base, providing a means for attaching any threaded piece, or of making a bolted assembly, or, with a disk, of retaining loose material. The speed, portability and ease of operation of the device are other factors enhancing its value.

The principle upon which studwelding operates is quite simple. The prepared stud, usually with a small quantity of flux held in a cavity at its base, is inserted into a gun; a ceramic ferrule is slipped over the base of the stud, and the gun is held in welding position against the metallic surface to which the stud is to be attached. A



Simple jig on this drill press stand locates studs for welding on gasoline pump part.

suitable source of direct current in conjunction with a timer unit powers and controls the gun. When the trigger is pulled the stud is automatically retracted by the gun's solenoid coil from contact with the metal surface, creating an electric arc between the stud and the metal to which it is to be joined. A pool of molten metal is formed, protected by the flux, and the automatic timer cuts off the current. When the solenoid is de-energized, the main spring drives the base of the stud into the pool of metal to join the two pieces in a secure fusion weld. The entire cycle usually requires only a fraction of a second, the time varying with the size of the work and the current input.

The weld formed is of the shielded arc type; the flux in the stud and the porcelain ferrule combine to protect the melt during the welding process. Complete fusion occurs, and the bond possesses good fatigue and tensile strength. Steel of carbon content up to about 0.30% can be welded without preheat, but preheating is recommended for higher carbon compositions. In such cases warming the surface to which the stud is to be attached may be done with a torch, and the stud can be welded to it immediately afterward in the usual way.

An important feature of the bonding is the use of the ceramic ferrule. It shields the arc, concentrates heat, protects the melt from oxidation, and serves as a dam to prevent squeezing out of flash when the stud is driven into the pool of molten metal. A clean bond results, and there is no need to trim or chip at the weld to permit turning down the nut or attaching the gasket or other member of the assembly. Threads on the stud do not extend completely to the weld end, but this is no disadvantage as the piece being fastened by means of the stud will take up the lower portion of its length. A tap with a hammer disposes of the ferrule after the weld is made.

The welding gun is powered with direct current. A NEMA rated 400-amp. d.c. welding machine is the conventional source of current, handling studs up to ½-in. dia. with a nominal length of welding cable.

Types of Studs

The studs are standard in sizes from ⅛- through ¾-in. dia., and lengths to 8 in. A wide variety of styles — plain, threaded, grooved, hooked, eyebolt, etc. — is available, and special studs are obtainable on order. Threaded forms are obtainable with different lengths of thread, with a shoulder, or with female thread. Grooved forms are useful for plug welding, or where a stud too short to be held in the gun chuck must be applied. Grooved forms are plain or threaded. When the welded fillet at the base of the stud must not extend beyond the diameter of the stud by

the full amount provided by the ferrule, studs with reduced base can be obtained. Split studs, opened like a cotter pin to hold insulation or other bulky material, are rapidly applied fasteners. Bent studs are convenient holders for metal strapping.

For construction work, several special fasteners speed operations. Zinc nuts and lead sealing washers are used over threaded studs to hold corrugated asbestos or sheet siding. Special studs are available to hold metal lath. Other types accommodate drive screws for fastening sheathing. The female types of threaded stud are useful for attaching pipe hangers and electrical equipment, while insulation pins, welded to the base metal and having large heads to offer holding surface, are used with noncombustible blanket insulation.

Eyebolt studs, hook studs, pointed studs, and rope hooks are useful when an attachment of one of these forms must be made to metal. They may serve as pipe carriers, sack holders, supports for rope, and for similar purposes in the handling of materials.

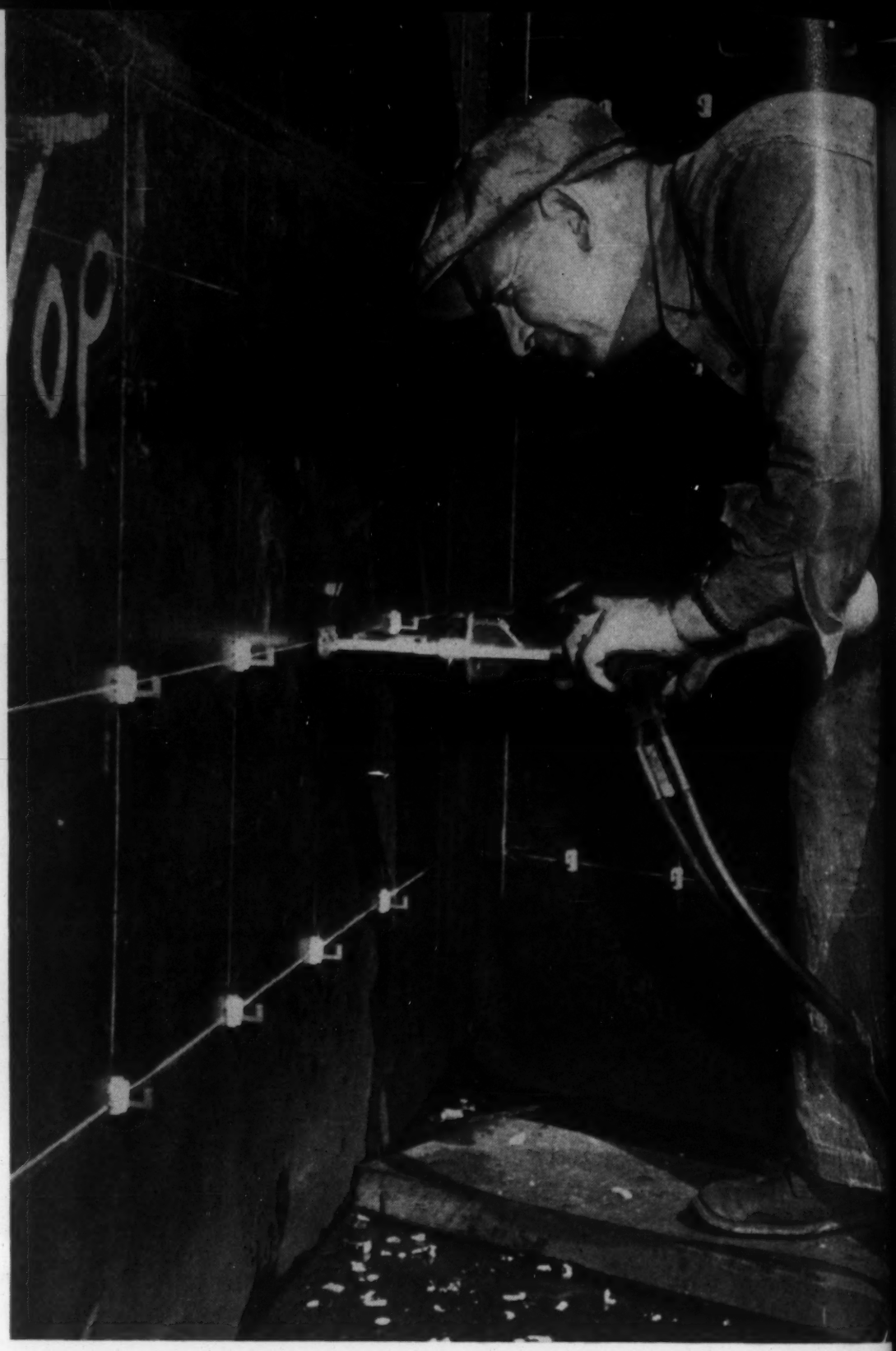
Studs are available in SAE 1020 and 1015 steel, and in 302, 304, 307, 309, 310, and 347 types of stainless steel. Almost any steel composition may be obtained as a special order, however. Studwelding with lead-free brasses and bronzes, aluminum, magnesium, and some of the Monels is still in the laboratory stage.

Advantages of Studwelding

As a means of fastening, welded studs fall between such mechanical fasteners as stud bolts, machine screws and rivets, and fusion welding. The fastener is permanently attached by welding at one end, and then permits a separable assembly to be made over the free end. Studwelding offers the following advantages over some of the more common methods of fastening.

Speed—The operation is fast. Studs can be welded into a metal base at the rate of about 20 to 30 per min. with the gun mounted in a production unit, and at about 100 to 200 per hr. when used manually. Set-up time is low, as the only adjustments necessary is the regulation of the current for the size stud being handled. For some jobs the positioning of the stud may be facilitated by the use of a simple template.

Strength—A strong bond is made. Extensive tests upon assemblies using welded studs resulted in failures consistently outside the weld, and at stresses of about 70,000 psi. or higher.



Special stud forms, such as those shown here, are available for a variety of applications.

Accuracy—The work is accurate. Use of adequate fixtures or templates makes possible the location of the studs to tolerances of +0.01 in. in height, +0.005 in. in location. The fixture used to guide the stud is relatively simple in most cases.

Portability—The stud welder is easily portable. The gun itself weighs only 5 lb., permitting its manual use almost anywhere. It becomes a valuable tool for field or maintenance work as well as in shop production. Its light weight makes it convenient for use by women employees also.

Operator Skill—No highly specialized skill is required. All of the procedure after the loading and positioning of the gun is automatic. Proper settings on the time control unit may be standardized for a given job, after which it is only necessary to pull the trigger.

Flexibility—The welder is adaptable to either production or field use. In the field the gun is complete in itself except for the timing unit and a source of current. For high production work in the shop, a production unit of one or more mounted guns may be set up, utilizing a pneumatic cylinder and a positioning fixture. The portable gun may be converted into an auxiliary production unit.

Applications

Studs can be attached to fairly light gage plate, though full strength in the welded assembly may not be developed because of lack of strength in the base plate. Following are the minimum recommended thicknesses of mild steel sheet or plate onto

which the studs can be welded:

Stud Dia., In.	Plate Thickness
Under ¼	20-gage min.
Under ¼	18-gage min.
Under ⅜	16-gage min.
Under ½	13-gage min.
Under ¾	3/16-gage min.

Studwelding has been especially useful for attachment of inspection covers, boiler manhole covers, and similar applications where welding on threaded studs saves drilling and tapping a hole for the stud bolt. Female threaded studs welded to beams have been used to attach pipe brackets and other hangers where adjustment by threaded attachment must be made.

The use of studwelding in the making of switchgear boxes for the electrical industry is typical of applications to light sheet. These boxes were formerly made by cutting rectangular plates for the five sides of the open box, and welding the edges. A flange around the top of the box and a plate at one side were also welded on to give sufficient material for conventional threaded studs at these locations. With the use of welded studs as fasteners, the box is brake-formed from one lightweight sheet, welded at the four sides only, then studwelded.

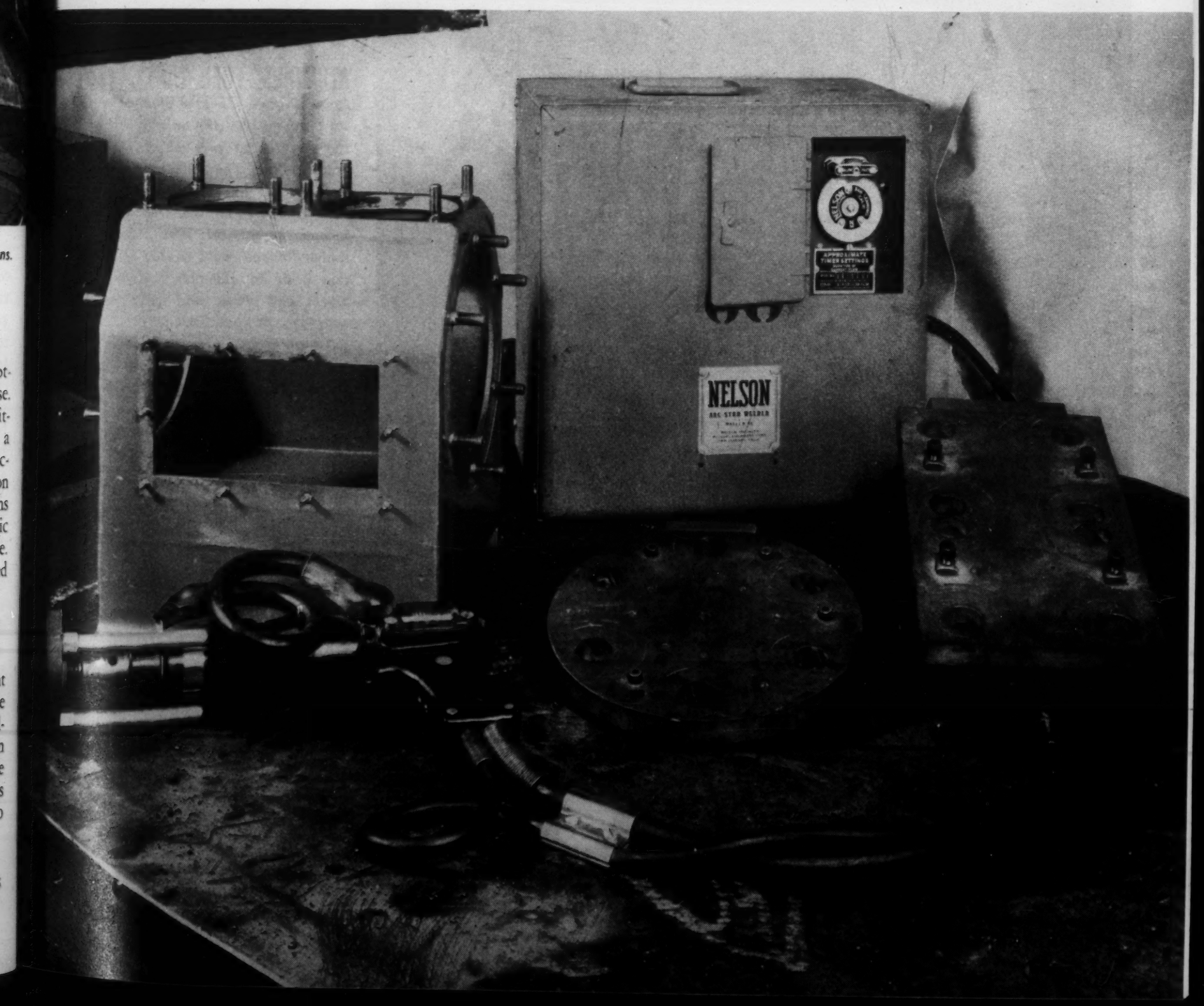
Locomotives have found in studwelding an answer to the problem of how to attach many small accessories to a steel structure. Horn, sandbox, cable brackets, cable run, clips for the lubrication lines, inspection covers, instrument panel, etc., are fastened to welded studs. In railway cars female threaded studs are welded to channels and attached to the sides of the car, and battens are attached by placing the batten in position over holes through the sides, then welding studs through the holes and fastening with nuts.

Welded studs make excellent spacers between metal sheets. They may be of female threaded type, or shoulder studs. Similarly, the studs are used to fasten a sheet metal cover over insulation, and to attach a plywood covering over steel. When a dead air space is desired over a steel or steel-framed surface, as for sound insulation, drive-screw studs are welded to the steel at regular intervals, furring strips are drilled and slipped over the studs and fastened with drive-screws, and the sound deadening insulation is nailed to the furring strips.

The welded stud is frequently a convenient means of handling work in process, even when it is not a part of the finished product. Studs welded to a workpiece, such as forging billets, provide a means of handling, and save the additional material that otherwise would be required on the billet. A studwelded hook often facilitates the handling of products which must pass through finishing solutions and ovens.

The savings in time, in material, and in labor, and the gains in accuracy, strength, and availability all add up to savings in cost. Studwelding is primarily a cost-cutting means of attaching fasteners to steel, and it has shown its ability to do so in a variety of industries.

Timer unit and studwelding gun shown with the templates by means of which studs are attached to the compressor housing, upper left.

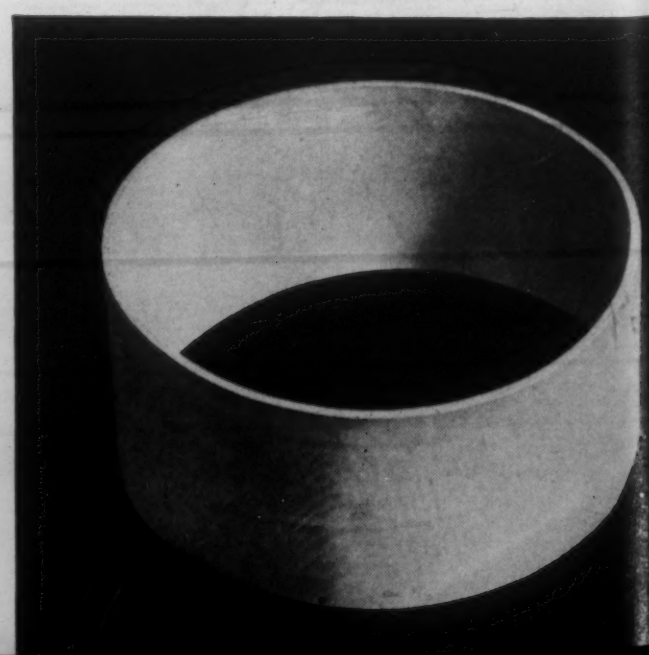


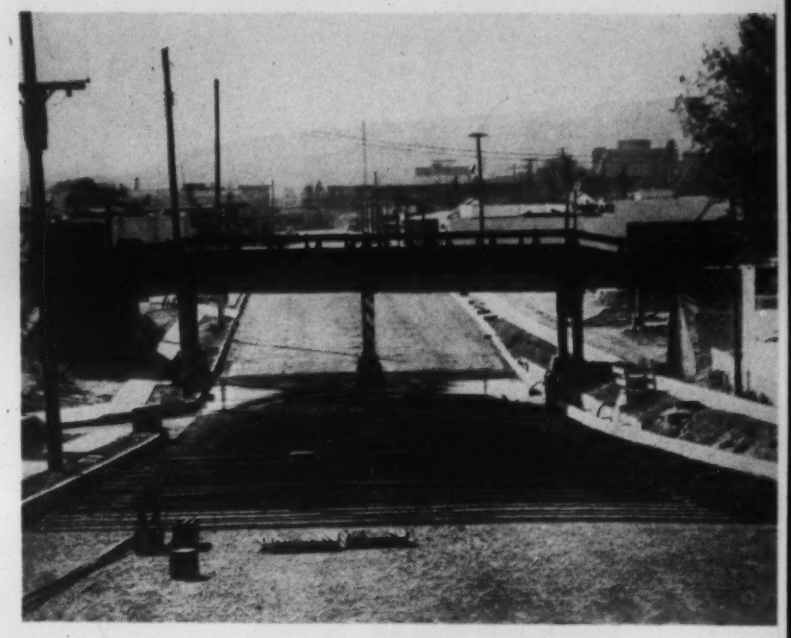
Materials at Work

Here is materials engineering in action . . .
New materials in their intended uses . . .
Older, basic materials in new applications . . .

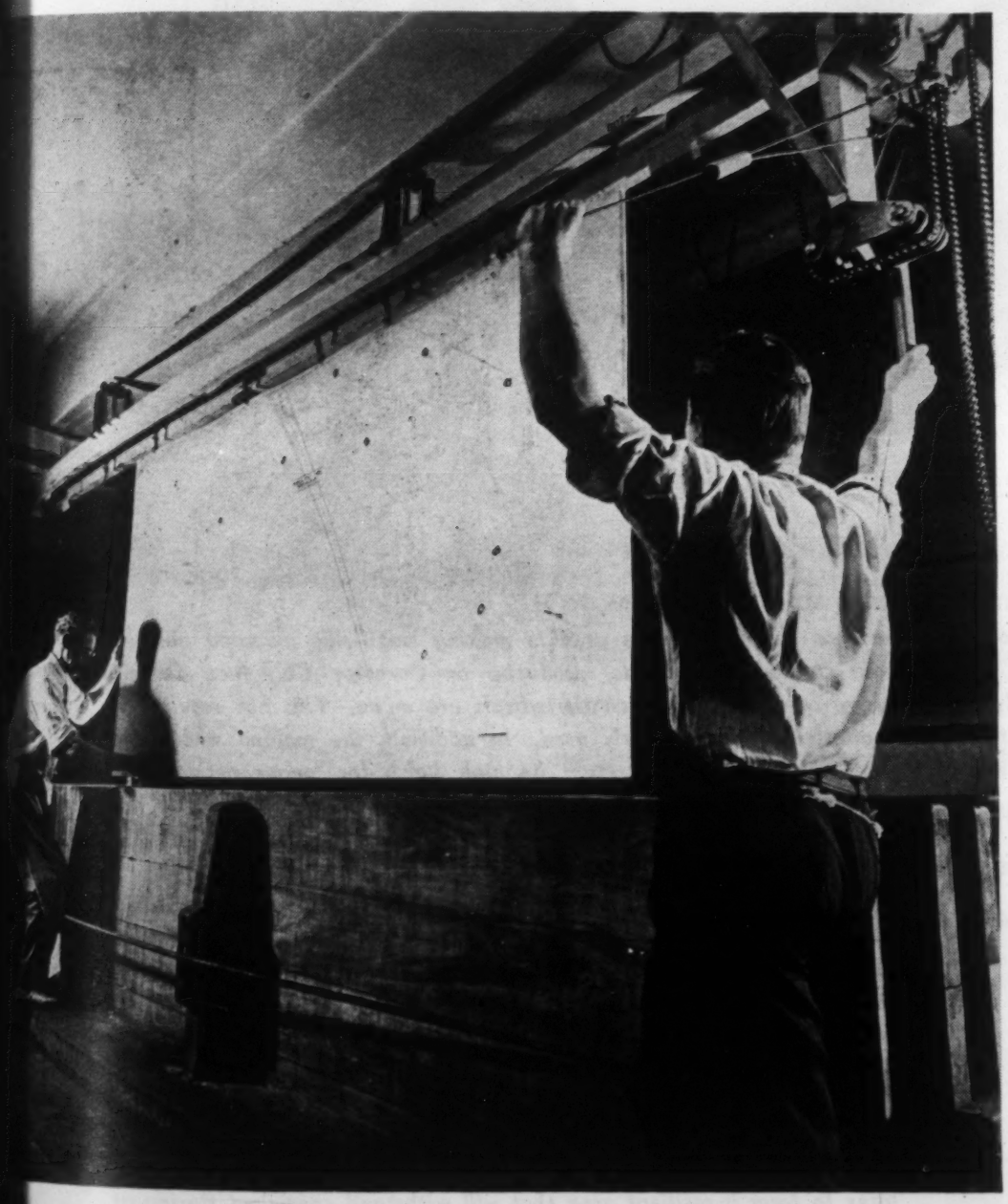
ALUMINUM FUEL TANK *Fabricated from 10-gage, 3S-½H aluminum, this fuel tank was welded throughout with a Heliarc HW-4 torch, a product of the Linde Air Products Co. The tank top and front side were formed from a single sheet of aluminum; the bottom and rear side from a second single sheet. Two steel inlet pipes, rubber-flanged, were riveted to the top section prior to assembly. Aluminum baffle plates, end plates, and sump complete the structure. No special jigs or fixtures were required in assembly operations since the inert gas-shielded arc-welding process produced a small heat spread and minimum warpage. Approximately 40 ft. of welding was required and total welding time, including preliminary tacking, was approximately 1¾ hr.*

GLASS FIBER-SILICONE RUBBER SLEEVE *Connecting high-temperature air ducts in military aircraft, this flexible sleeve permits the passage of air at 550 F for heating and de-icing purposes. Produced by the Connecticut Hard Rubber Co., New Haven, Conn., and consisting of a glass fiber base reinforced with silicone rubber, it withstands internal air pressures of 5 to 10 lb. without leakage and remains flexible at temperatures as low as −75 F. Severe test specifications require that this sleeve be subjected to −65 F for a period of 50 hr., followed by 500 hr. at 400 F and 5 hr. at 450 F without failure.*

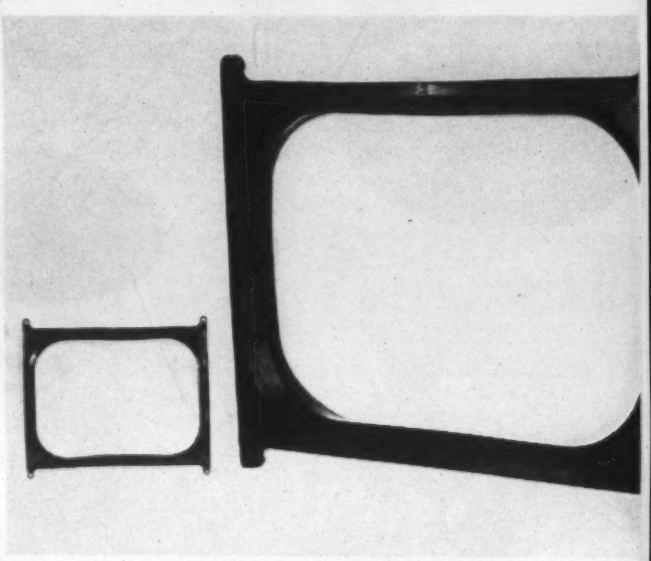




WELDED WROUGHT IRON PIPE GRID *A water and anti-freeze mixture, heated to 160 F by subterranean springs, is pumped through this pipe network embedded in concrete to melt snow and ice from a portion of the Dalles-California Highway near Klamath Falls, Ore. A 2-in. pipe runs from the well to the pavement and then parallel to the road for a distance of about 400 ft. In the pavement are embedded 15,000 ft. of ¾-in. wrought iron pipe, made up into one grid for each of a series of 30-ft. road panels. Each of these panels is connected with the 2-in. water main by valves. Welds are used throughout. The pipe was asphalt-coated before being laid in the concrete. Wrought iron was used because of its resistance to corrosion and because its coefficient of expansion is virtually the same as that of the concrete, thus keeping the bond and minimizing the danger of cracking the concrete.*

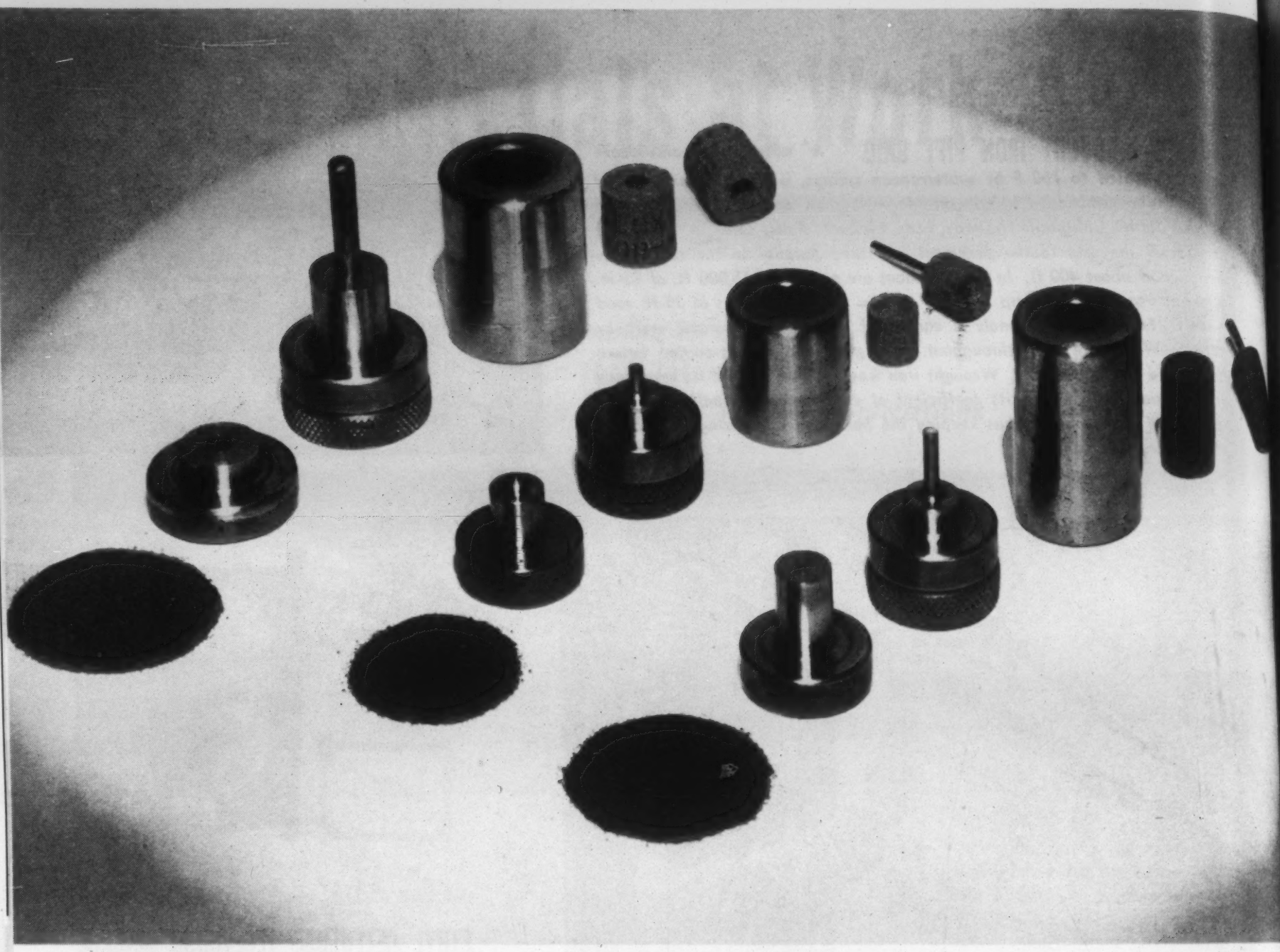


WOODEN TANKS *Because of its high resistance to decay, high insulating properties, and low heat conductivity, wood is used in tank construction for many industrial processes. Of particular advantage over metal is wood's resistance to acid and corrosion. Because of this, large photo developing tanks are among the newest applications of wood to tank construction. Produced by Wendnagel & Co., Chicago, Ill., these tanks or vats can be made from different woods in any shape or size to meet varying requirements. Since wood requires no painting, maintenance costs are minimized.*

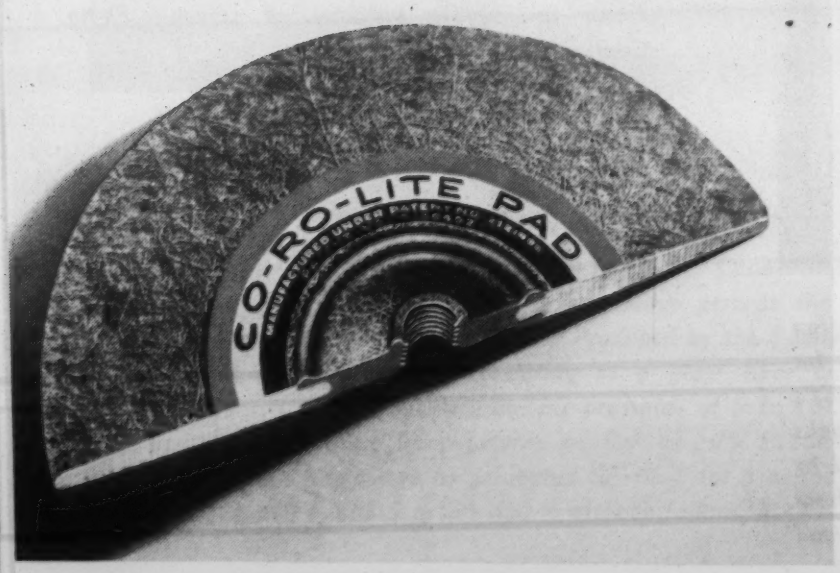


ETHYL CELLULOSE TELEVISION MASKS
Framing the front end of the cathode ray tube in the new Dumont television receivers, this black mask is injection molded of ethyl cellulose by the Collyer Corp., Summit, N. J. Large illustration on right shows front view of mask used on 52-sq.-in. receivers; back view in inset photo shows molded-in rib construction for added strength. The mask material is tough, resilient, and sufficiently flexible to provide easy assembly without damage to tube. The mask is molded with a dull finish to improve visibility of screen. Photo: Courtesy Hercules Powder Co.

Materials at Work



CEMENTED CARBIDE MOLD LINERS *To reduce wear on the steel molds used in making small-size mounted abrasive wheels, Carboloy cemented carbide liners are used. These carbide-lined molds, produced by Carboloy Co., Inc., Detroit, Mich., resist the gouging action of the extremely hard abrasive crystals from which the wheels are made. This has resulted in an increase in mold life from five to ten times that of the all-steel molds formerly used. In addition, the molded wheels are more easily removed from the molds, due to the ability of carbide metal to retain its high finish for longer periods. No alterations in mold design were required when changing over from all-steel to carbide-lined molds, the barrels being merely lined with the hard carbide metal.*



RESIN AND LATEX-BONDED PADS *Molded from sisal fibers impregnated with plastics, this one-piece sanding pad, a product of the Columbian Rope Co., Auburn, N. Y., provides the resiliency, flexibility, and toughness required for sanding and polishing operations on all types of surfaces, curved or flat. The hub section is made from fibers impregnated with a thermosetting resin. This hard center is drilled and threaded for the arbor. The outer, or working section, is made of the same type sisal which has been corded and needled into a mat of interlocking fibers. This section is bonded with Neoprene latex to form a resilient area that will withstand continued flexing at high speeds. The Neoprene bond resists deterioration from friction heat and is not affected by contamination with oil or grease. In use, emory or sandpaper is fastened to the disk by a locknut on the drive shaft.*

Materials & Methods Manual

This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and application

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Cemented Carbides

by Kenneth Rose, Western Editor, Materials & Methods

Cemented carbides are tough, very high hardness materials that serve industry both as a tool material and as a wear resistant material in many types of machinery and other products. And because of other exceptional qualities, cemented carbides have begun to find other uses, notably in the field of high temperature service. This manual describes the characteristics, properties and uses of the various types of cemented carbides; it also gives some helpful information on attaching carbides to tools, and on grinding and polishing these materials.

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Introduction

Modern living calls for speed, and speed means light weight as well as fast-moving machinery. Lightening the weight of a piece of mobile equipment is frequently accomplished by using stronger materials for stressed parts, and increasing the unit loading. Higher speed requires greater wear resistance also, and one result has been the increasing use of harder, stronger parts in much of today's machinery.

Forming these tougher materials at high speed, and processing abrasive materials, has compelled industry to search constantly for harder tool materials. Unfortunately, tool materials require properties other than hardness, so that even when industrial diamonds were made available the search continued. Finding a tough, moderately priced material of very high hardness, excellent abrasion resistance, and of such a nature that its supply would not be in jeopardy either in time of war or from economic rivalry was a problem finally solved with the development of the hard carbides of several metals and of methods of utilizing them industrially.

The cemented carbides, result of this search, are primarily "hard" materials. They are superior to the hardest steels man has developed, and, with several carbides of nonmetallic elements, most closely approach in hardness that natural crystal of pure carbon, the diamond. They have begun to win uses for several other properties, however, notably in the field of high-temperature service. They are synthetic materials—manmade competitors of that hardest of all substances, the diamond. While the hardness value of the diamond as determined by the Knoop method would be from four to six times that of the hardest of the cemented carbides, these and a few other carbides, with a few such gem materials as the sapphire, hold the top of the list of hard materials below the diamond to themselves.

The cemented carbides have been called manmade metals, and they resemble metals in their physical properties as well as in metallographic structure. The particle size of the carbide constituent in a sintered compact is comparable to the grain size of the constituents in a fine-grained steel, and in strength properties, electrical conductivity, metallic lustre, etc., the sintered carbide resembles the familiar metals and their alloys. Conversely, the carbides are chemical compounds of metallic elements, and so are in a class not usually regarded as metallic in the same sense as are the elemental metals and their alloys. These particles of chemical compounds are bound together by the metal matrix with which they form the cemented carbide of commerce.

The materials commercially important as cemented carbides are principally tungsten carbide, tantalum carbide, or titanium carbide, in a metal matrix which is usually cobalt.

The metallic carbides in this group of hard materials are unworkable by practical methods. As this would sharply limit their range of usefulness, the method of fabricating that has made the carbides practical industrial materials was devised. The pure carbides are crushed and ground to powder, a matrix material is added, also in powder form, and the mixture is then molded and heated to a temperature that will sinter the matrix. The cemented carbides as produced for industry are then tiny particles of very hard carbide materials in a matrix of a relatively soft metal.

From this it will be seen that the term "sintered carbides," sometimes used to denote these hard carbides in matrix, is not accurate in the strict sense of the term, but is somewhat truer than "cemented carbides." The carbides are not sintered in the heating operation, but are bound together by the matrix metal, which is sintered. Silicon carbide is formed by actually sintering the carbide material, and can correctly be termed a sintered carbide in its fabricated form.

While the cemented carbides are formed by the methods of powder metallurgy, and are therefore prepared by binding together discrete particles of hard carbides, the metallographic structure of the finished piece closely resembles that of an alloy in which crystalline constituents have been precipitated from a molten solution or mixture. The particles of carbides are of a size comparable to many of the crystalline grain sizes in a fine-grained steel. Voids are usually held to a low value unless a somewhat porous structure is desired.

History

The French chemist Henri Moissan, who prepared crystals of carbon in molten iron to produce the first synthetic diamonds, also produced the first tungsten carbide. It was in 1896, while Moissan was experimenting with high temperatures in his electric furnace, that the famous Frenchman discovered the tiny pieces of hard carbide in the furnace residues. He tossed the particles of unmanageable material aside as worthless.

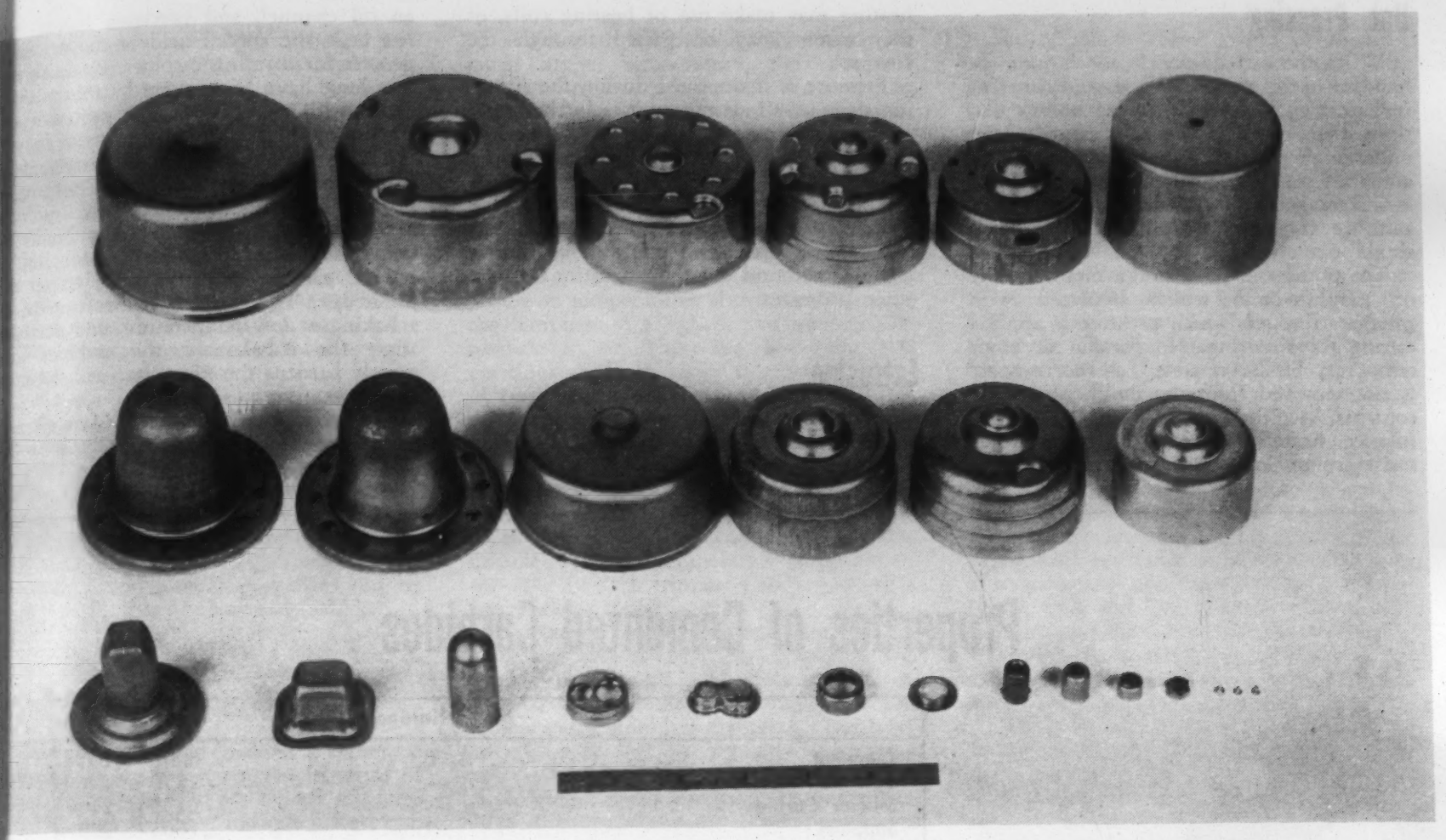
During the First World War German engineers, searching for a substitute for diamond dies for drawing small-diameter wire, hit upon the idea of crushing the unformable hard pieces of tungsten carbide and of forming the powder so produced. A metal matrix was used to cement the reconstituted hard material into the desired shape. From this cemented material Germany produced most of its fine filament wire for electric lamps during its period of shortages of every conceivable commodity.

At the end of the First World War blocks of the cemented tungsten carbide were sold in this country under the name of Widia metal. The name was taken from the German "Wie Diamant," which compared its great hardness to that of the diamond. It sold for about a dollar a gram, or approximately $500 per lb. In spite of its hardness and the advances made in metalworking technology, it was not entirely successful in its first appearance before American industry. The blocks of cemented carbide were almost as difficult to apply to cutting tools and the like as the original crystals had been. Sensing the possibilities of the material, however, General Electric Co. bought up the American rights to the German patents. About 1928 the process of molding the crushed carbide to shapes close to that desired in the finished piece, and then sintering, was worked out, and uses for the hard material expanded greatly. One result was the beginning of the carbide cutting tool industry on a large scale.

With expanded demand for carbides came large-scale production and steadily lowered prices. The price of the German importations had been about $1 per gram, but the present price of American-made superior carbide materials is of the order of 6 to 7c per gram. In fact, standard mass-produced carbide blanks are priced at about 4c per gram, and a standard carbide tool is roughly comparable in price to a similar one in high-speed steel.

Developments in powder metallurgy techniques have helped to speed the expansion of carbide applications. The cemented carbide industry has likewise assisted the growth of the rest of the powder metallurgy field. Methods of grinding the powders, presses of adequate size, and furnaces with the proper atmosphere controls have been developed as the uses of metal powders and carbides widened, until today methods and machinery are well standardized.

The carbide industry is now wide open so far as fundamental methods and patents are concerned. All basic patents upon the process have expired, and patents still in force are those evolving from the more recent research of some of the dozen or more firms prominent in the field with those of individual researchers. Most of the present patents relate to special processing methods of individual companies.



Typical small pieces drawn with carbide dies. Long runs may be held to close tolerances. (Photo: Courtesy Allegheny Ludlum Steel Corp.)

Powdered Carbides

The basis of most cemented carbides is tungsten carbide. It is prepared by heating an intimate mixture of powdered tungsten metal and finely divided carbon, usually lampblack, to a temperature of 2500 to 2700 F. The powder is then ground, usually in a ball mill with carbide balls, and screened to obtain uniform particle size. Extreme fines are rejected, and oversize particles are reground.

Tantalum and titanium carbides are usually prepared by heating the oxide of either metal with carbon, the temperature required being in excess of 2700 F. The carbide is then processed, as was the tungsten compound.

An essential part of the grinding in most processes is the addition and intimate mixing of the powdered matrix metal. The grinding may be continued for several hours or much longer, depending upon the grain size desired for the particular application for which the material is intended. Particle size of the carbides is usually of the order of 1 to 15 microns. The prolonged grinding has the effect of coating each carbide particle with a nearly continuous layer of the softer binder metal, thus insuring good cementing during sintering.

Forming

The carbide pieces may be formed by any of three methods:

(1) *Cold pressing*—the powder is preshaped on small presses, then presintered and finally formed and sintered.

(2) *Hot pressing*—combining the operations given for cold pressing, the piece is pressed and sintered in one operation.

(3) *Extruding*—the powder is handled similarly to cold pressing, except that the preshaping is done in an extrusion press.

Cold Pressing

A lubricant is added to the powdered material when forming is to be done by cold pressing. Paraffin or stearic acid, to about 1% of the weight of the powder, serves as a temporary binder, and for some applications permits pressing to be done in rather small machines, sometimes pill presses. Pressures used are about 5 to 30 tons per sq. in. The powder is pressed in a mold, with the batch of powder loosely packed. It may occupy three times the volume of the preshaped piece. This preshaping can also be used to produce ingots of flat or cylindrical form that can be reshaped later.

The cold pressed material is softer than chalk, and can be broken between the fingers. To increase its strength so that it may be handled, a presintering operation is performed. The compact is fired at a heat considerably below that needed to fuse the binder. When special shapes are to be produced from a compacted ingot, the presintering can be carried to the point that the piece can be machined to the required shape. A final sintering at about 2650 F develops full hardness.

Decarburization of the compact during sintering is prevented by maintaining a neutral or a reducing atmosphere in the furnace. Hydrogen is most used, but compacts containing tantalum or titanium carbide are sometimes sintered in a vacuum. The treatment usually requires from a half-hour to an hour. The cobalt binder flows sufficiently to fill most of the voids, and has a dissolving action upon the carbides that results in the formation of a small amount of carbide-cobalt solution at the surfaces of the carbide grains. The particles of carbide are drawn more closely together by the surface tension of the solution, and are more firmly bound by it upon cooling. As a result of partial precipitation of the carbides from this solution upon cooling, the carbide grains are larger after sintering than before. The overall volume of the compact shrinks considerably, however—sometimes as much as 40%.

The shrinkage in volume is indicated by the gain in density. The specific gravity of the presintered compact is about 9; for the sintered piece it may run as high as 15.

Physical properties of the finished carbide piece can be controlled by the conditions of sintering among other factors, such as temperature and time in the furnace.

Hot Pressing

When the carbide part is too large to be handled in the existing presses and sintering furnaces, or when it involves hollow sections that could not be formed in dies under high pressure, or for extremely long and thin sections, the hot pressing method is advantageous. It combines the steps in forming as given for cold pressing into a single operation.

The powders are fed into a mold, usually of graphite-base, which is fitted with plungers through which pressure is applied during the sintering. No paraffin or other temporary binder is added, as the compact is not removed from the mold. Mold and contents are then placed in a sintering furnace, heated by electricity, using either resistance or induction heating. Resistance heating may make use of heating coils, or the current may be passed through the compact.

Pressure is maintained during the sintering stage to fill all the cavities in the mold, and to prevent formation of gas pockets in the compact from gases liberated during the process.

The hot pressing method of forming carbide parts has made steady gains in recent years because it offers a fabricating method to round out the limitations of the other processes.

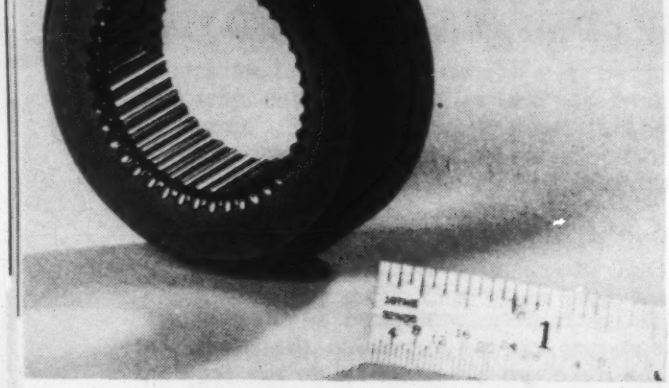
Extrusion

Formation of long round, square, or other shaped rods; tubes, spirals, and similar forms; twist drill sections, with or without an oil channel, and precision boring has been the special field of the extrusion process for forming carbides. Pieces several feet long have been made by this method.

As with other extrusion processes, extrusion of carbide forms consists of squeezing the powder through an extrusion die that gives it a definite form. The powder is prepared for extrusion by mixing with a small amount of a temporary binder so that it maintains the desired form until it can be given a heat treatment to set the plasticizer. This first treatment consists of a baking at low temperature, and does not affect the cobalt nor the carbides, but merely hardens the plasticizer added before extrusion.

The extrusions are next presintered, and finally sintered at about 2600 F, as in the cold pressing methods.

Properties of Cemented Carbides



A cup with serrated rim is drawn in this carbide die insert. (Photo: Courtesy Allegheny Ludlum Steel Corp.)

The outstanding property of all of the cemented carbides is their high hardness. This appears in resistance to indenting and in resistance to abrasion. Two other properties that make it especially useful industrially are its high compressive strength, permitting its use in such applications as cutting tools and dies, and its high modulus of elasticity. There are many combinations of carbide materials and matrices, and these afford different properties in the finished piece.

Hardness values running beyond the range of hardened tool steels can be expressed in terms of the scale used for minerals. Moh's Scale covers hardnesses from that of the soft mineral talc to the hardest known substance, the diamond, in a numerical scale from 1 to 10. The intervals in the scale are not uniform, but simply indicate progressively harder materials. To evaluate hardness more accurately in the high ranges, the Knoop Hardness, given as Brinell equivalents, of some of the minerals at the upper end of the scale is here given, along with some of the hardest synthetics:

	Moh's Hardness	Knoop Hardness
Diamond	10	6000 to 6500
Boron Carbide	—	2250 to 2260
Silicon Carbide	—	2130 — 2140
Sapphire	9	1600 — 2200
Aluminum Oxide	—	1635 — 1680
Tungsten Carbide (Cabalt Binder)	—	1050 — 1500
Topaz	8	1250
Quartz	7	—
Feldspar	6	—

These values, quoted in Industrial Diamond Review, *are questioned by some authorities, who give the sapphire a slightly lower hardness and assign to the cemented carbides a range that extends a little above that of the sapphires.*

Carbides

Tungsten carbide—the most widely used of the carbide materials. It forms the basis for nearly all of the cemented carbides made up with mixed metallic carbides. Its lower cost and high hardness are two of the important features that give it advantages over other metal carbides as an industrial material.

Tantalum carbide—included in carbide combinations primarily to impart resistance to "cratering." It was found to have this property in early studies of tungsten carbide cutting tools. The steady impingement of the chip just behind the cutting edge of the tool formed a depression in the surface of the carbide material, and reduced tool life. Addition of a small percentage of tantalum carbide to the tungsten carbide improved the cutting tool in this respect.

Titanium carbide—serves in much the same way as tantalum carbide in cutting tools of mixed carbides. Titanium carbide is cheaper than the tantalum compound, and is sometimes substituted for it for that reason. It also possesses unusual high-temperature properties, and is used alone in some applications requiring such properties.

Tungsten-titanium carbide—a double carbide of the two metals rather than a mixture of the two normal carbides. It reduces cratering in combinations, and also possesses good corrosion resistance. Another feature of the double carbide that sometimes favors its use is its ability to take a high finish with relative ease. This is a patented composition.

Molybdenum carbide—used to some extent in Germany during the war as a substitute for the harder carbides, then unobtainable, for cutting tools. It gave decidedly inferior performance, and was not used in this country except experimentally.

Chromium carbide—another wartime material, but one that is expected to fit into the widening uses of carbides. Chromium carbide has excellent corrosion resistance, and hardness is good.

Vanadium carbide—used in Germany during the war.

Columbium carbide—an occasional ingredient in mixed carbides.

Matrix Materials

Cobalt—by far the most used binder in cemented carbides. It is more ductile than other common matrix materials suitable for use with the carbides, and possesses good strength.

Nickel—also suitable for use as a binder, and used to some extent, especially during the war, for cemented carbide cores in armor-piercing projectiles.

Iron—supposed to have been used to

some extent as a matrix in carbide cores for armor-piercing projectiles by Germany. Iron is not a commercially used binder in American practice.

(The three metals listed above are the most generally used matrix materials because they form double carbides with the carbide ingredients, insuring good wetting and bonding in the sintered compact).

Tungsten—used as a metal binder in a few specialty carbides, in addition to its use as a carbide. It imparts high-temperature hardness to the binder, and is used in some carbide preparations intended for high-heat service.

Platinum—for certain applications requiring high chemical resistance platinum is used as the matrix.

While properties of the sintered compact can be influenced by (a) the carbide or carbides used, (b) the binder used, (c) the proportions of carbide and binder, and (d) the conditions of compacting and sintering, a few general properties can be given for all types of cemented carbides.

Room Temperature Hardness

The indentation hardness of a cemented carbide has already been given in terms of Knoop's hardness, and its scratch hardness in Moh's scale has been indicated. Rockwell hardness of commercial carbides, read on the "C" scale but taken with a 60-kg. load instead of the standard 150 kg. load, will give a closer comparison with the usual values for hardened steel. The range is 85 to 93 Rockwell hardness.

Red Heat Hardness

An outstanding property of the cemented carbides is retention of their exceptional hardness at high temperatures. This is one of the factors in their excellent performance as cutting tools, where the temperature of the tool at the cutting edge may rise considerably. Some of these high-temperature hardness test results are given below:

at 1300 F, Rockwell hardness (60-kg. load) 83.5 to 84.5
Brinell hardness 600 to 680

temperatures at which tool materials have softened to the same hardness value

Carbon tool steel	650 F
High-speed steel	825 F
Cemented carbide	1550 F

In addition to maintaining hardness to a much higher temperature, the cemented carbides are not subject to "drawing" by repeated heating to elevated temperatures. When a carbide piece is heated to a temperature at which appreciable softening begins to occur, the original hardness is regained upon cooling.

In general, cemented compositions chiefly containing tungsten carbide are not recommended for service requiring prolonged exposure to temperatures above a red heat, or the temperature at which tungsten carbide oxidizes in air. There are, however, compositions made to resist destructive effects of temperatures above 1800 F in air. These contain no tungsten; they contain chiefly titanium carbide. They are not used in tools and dies for work at room temperature, because the superior fine grain requisite to cutting edges and drawing dies is attainable chiefly in compositions containing tungsten carbide. The high temperature compositions are used in flash trimming tools and other hot working tools.

Strength—Tensile strength varies considerably with proportions of carbide and binder in the composition. In general, cemented carbides have comparatively low tensile strength, rather low impact resistance overcome in use by properly supporting the carbide, high compressive strength, and high modulus of elasticity. Tungsten carbide with a cobalt binder in best percentages will have about half the tensile strength of tempered tool steel, which is still high and ample for most purposes. Compressive strength will be well above that of the tool steel, and modulus of elasticity will be about 2½ times that of steel. The elongation of sintered carbides is practically zero. Modulus of elasticity has been fairly well established at 73,000,000 psi. or higher.

Wear Resistance—Cemented carbides show exceptionally high wear resistance, as would be expected from the combination of high indenting hardness and high scratch hardness. Test data are not readily correlated, but wear was reported as negligible in a shot blast test of bars of cemented carbide, using No. 72 steel shot at 100-lb. pressure for several hours.

The best evidence of the exceptional wear resistance of cemented carbides is in results of actual service of die blocks and similar pieces in industry, in comparision with the performance of similar pieces of hardened tool steel. The carbide parts usually show an advantage of 10 or 20 to 1 or higher in service life.

Surface Finish—Most grades of cemented carbides are capable of taking a high surface finish. Grinding and lapping will develop a surface smoothness suitable for master gage blocks. Certain grades are especially adaptable to very high finish.

Thermal Expansion—In the range of temperatures from 68 to 1290 F the coefficient of expansion of typical cemented carbides is about one-half that of steel.

Magnetic Properties—The carbides themselves are nonmagnetic, but the cobalt (or nickel) serving as the binder is weakly magnetic. The cemented carbide is, therefore, very slightly magnetic. In grades having only a few percent of cobalt the magnetism will be barely perceptible.

Corrosion Resistance—Corrosion resistance of these synthetics is in general limited by the resistance of the binder material to attack. For this reason a few grades of cemented carbides intended for service where exceptional resistance to chemical attack is a requirement use platinum as a binder. Nitric acid and hydrofluoric acid will attack carbides themselves, the former slowly. Resistance to atmospheric corrosion is exceptionally good, and will compare favorably with that of stainless steel.

Density—Both tungsten and tantalum are heavy metals, while cobalt and titanium are much lighter. A tungsten carbide composition containing 3% of cobalt binder will have a specific gravity of about 15.25. Another standard composition, tungsten carbide with 20% cobalt binder, has a specific gravity of about 13.55. Small percentages of titanium carbide will lighten the material still more, and the lightest of the standard carbide formulations is a titanium carbide with about 30% cobalt binder, with a specific gravity of only 5.5.

Range of Sizes

Cemented carbide parts made by the cold pressing method are limited as to size by equipment requirements, but the hot pressing technique is more flexible in scope as to size and shape of parts. Sintered compacts are now being produced that are as much as 84 in. in length. A deep drawing die, made as a one-piece ring, had an inside diameter of 24 in. These are unusually large, but strip to 60 in. in length is produced quite commonly. Carbide parts weighing well over 100 lb. each have been produced commercially.

Some Standard Cemented Carbide Compositions

The makers of cemented carbides have found that certain formulations fit most of the general applications for the materials, and a fairly well defined set of types is standard in the industry. This does not mean that any cemented carbide manufacturer can produce all of the types given, as some are the patented product of a single maker. Likewise, the compositions given must be interpreted broadly, as the makers may vary a given formulation slightly to fit a specific application, and common formulas are not agreed upon by all producers.

Most applications outside the cutting tool field use a cemented carbide consisting of tungsten carbide and cobalt binder, unless the application is of a highly specialized nature.

The most generally accepted formulations are given below.

Tungsten carbide, 3% cobalt binder—the hardest cemented carbide practicable. More brittle than compositions having more cobalt binder. As a tool material the 3% cobalt type is used for precision machining, where light cuts will be taken and stresses will not be high. Hardness is affected by the particle size of the carbides.

Rockwell Hardness (A scale)	92.5 to 93
Specific Gravity	15.25

Tungsten carbide, 6% cobalt binder—slightly less hard than the low-cobalt type.

As a cutting tool this composition is used for finish cuts, and especially for cast iron, nonferrous metals, and nonmetallics such as thermosetting plastics.

Rockwell Hardness (A scale) 90 to 92
Specific Gravity 14.85

Tungsten carbide, 6 to 9% cobalt binder—decreasing hardness as binder content increases. Primarily for cutting operations producing a discontinuous chip, and for noncutting operations not subject to shock. This type is suitable for roughing and semifinish cuts.

Rockwell Hardness (A) 89.5 to 91.5
Specific Gravity 14.60 to 14.85

Tungsten carbide, 9 to 12% cobalt binder—higher shock resistance than the preceding material. For heavy roughing cuts in cast iron or other materials giving a discontinuous chip, and for noncutting operations involving limited shock.

Rockwell Hardness (A) 87.5 to 90
Specific Gravity 14.20 to 14.60

Tungsten carbide, 20% cobalt binder—a shock-resistant material, used primarily for noncutting applications. It goes into such parts as forming dies, rolls and plungers.

Rockwell Hardness (A) 85 to 87
Specific Gravity 13.55

Tungsten carbide, 25% cobalt binder—a high-cobalt formulation intended for applications in which shock resistance must be unusually high.

Rockwell Hardness (A) 84 to 85.5
Specific Gravity 13.20

Tungsten carbide, about 10% tantalum carbide, about 6% cobalt binder—primarily a cutting tool material, intended for finish cuts in tough materials giving a continuous chip. Low-carbon steels, Monel metal, and stainless steels are metals of this sort. The percentage of tantalum carbide used is rather variable.

Rockwell Hardness (A) about 91 to 92
Specific Gravity about 14.70

Tungsten carbide, about 10% tantalum carbide, about 12% cobalt binder—a cutting tool material for roughing cuts in tough, stringy metals that give a continuous chip. Also for drawing dies.

Rockwell Hardness (A) about 87 to 88
Specific Gravity about 13.90

Tungsten carbide, about 10% titanium carbide, about 6% cobalt binder—primarily for finish cuts in materials giving a continuous chip.

Rockwell Hardness (A) about 92 to 93
Specific Gravity about 11.20

Tungsten carbide, less than 10% titanium carbide, about 8% cobalt binder—primarily for roughing cuts in materials giving a continuous chip.

Rockwell Hardness (A) about 91.5 to 92.5
Specific Gravity about 12.80

Tungsten carbide, to 20% titanium carbide, about 7% cobalt binder—a special purpose material for maximum resistance to abrasion where shock does not figure.

Rockwell Hardness (A) about 92 to 93
Specific Gravity about 9.00

Tungsten carbide, with about 10% each of tantalum and titanium carbides, about 8% cobalt binder—for steel cutting in general.

Rockwell Hardness (A) about 91.5 to 92.5
Specific Gravity about 11.7

Tungsten carbide, with tantalum and titanium carbides, about 12% cobalt binder—for steel cutting in general.

Rockwell Hardness (A) about 90.5 to 91.5
Specific Gravity about 11.6

Tungsten carbide, with tantalum and titanium carbides, about 15% cobalt binder—for steel cutting in general.

Rockwell Hardness (A) about 89.5 to 90.5
Specific Gravity about 11.4

Titanium carbide, 20% cobalt binder—high-temperature cemented carbide, sometimes made with small amounts of other carbides to resist oxidation. Suitable for service to about 1800 F or higher. Not primarily a cutting tool or wear resistant material.

Rockwell Hardness (A) about 91.0 to 92.0
Specific Gravity about 5.5

Tungsten carbide, tungsten titanium carbide, cobalt binder—a formulation in which the double carbide is added to provide greater strength at high hardness. It is used as a cutting tool material where cratering resistance and high abrasive resistance must be combined, as in the machining of sand-cast steel and dirty forgings. Percentages of the ingredients are varied, tungsten carbide content being increased when abrasive resistance must be exceptionally high.

Titanium carbide, with tungsten and nickel binder—a high-temperature material intended to resist oxidation for long periods of exposure to high temperatures. Used to hold glass during annealing.

Tungsten carbide, with 10% platinum binder—a highly corrosion-resistant cemented carbide used in the chemical industry where high hardness and wear resistance must be combined with excellent chemical resistance.

Rockwell Hardness (A) 91.8
Specific Gravity 15.5

Because of the noncorroding binder used, this material will resist the action of strong mineral acids, hot or cold, up to fairly high concentrations. Nitric, sulfuric and hydrochloric acids have little effect on it at room temperature or when boiling hot, but hydrofluoric acid and hot concentrated nitric acid may cause attack.

Uses of Cemented Carbides

When the extreme hardness of tungsten carbide was first harnessed through the cementing technique, the material was prepared as a slab or block and drilled with a very small hole to be used as a wire-drawing die. It did the work of a diamond die, was fabricated in the same general way as was the diamond die, and seemed to offer very limited possibilities of other uses. Development of the techniques of powder metallurgy opened wide new fields to the hard material, and today it is the basis of new methods in metal cutting, has set sensational records in metal forming, has won a place in mining, in chemical industry, in high-temperature equipment, etc.

Classifying some of these typical uses of cemented carbides must be done upon a somewhat arbitrary basis. For instance, a chemical spray nozzle might be made of a platinum-bonded carbide first of all because of the wear resistance of the carbide, but the feature that would distinguish it among other carbide applications would be its high resistance to corrosive attack. Similarly, in most uses of carbides there are several features that influence its selection.

Cutting Tools

The largest single use for cemented carbides is in the manufacture of cutting tools. Development of tipping methods, which permit the use of a small block of the expensive hard material in a block of relatively soft and inexpensive metal, have stepped ahead with the production of carbides, so that the economies obtained by higher rate of metal removal have been increased by low tool material costs. These tipping methods are now almost universally applied to cemented carbide cutting tools.

Selection of grade of carbide for a cutting tool depends upon the material being cut. A broad guide to selection of type of carbide has been given under the listing of carbide materials. A chart of grades of carbides listed by trade designations, classified according to suitability for cutting various materials, has been prepared by the Metallurgical Committee of General Motors Corp. The various materials are not rated within each group, but all carbides offered by the leading makers as suitable for a given cutting application are listed for comparison. Carbides within a given group are not necessarily interchangeable on a specific job, however.

C-1 Roughing cuts—cast iron and nonferrous materials.
C-2 General purpose—cast iron and nonferrous materials.
C-3 Light finishing—cast iron and nonferrous materials.

C-4 Precision boring—cast iron and nonferrous materials.
C-5 Roughing cuts—steel.
C-6 General purpose—steel.
C-7 Finishing cuts—steel.
C-8 Precision boring—steel.
C-9 Wear surfaces—no shock.
C-10 Wear surfaces—light shock.
C-11 Wear surfaces—medium shock.
C-12 Wear surfaces—heavy shock.
C-13 Impact service—light.
C-14 Impact service—medium.
C-15 Impact service—heavy.
C-16 Impact service—extra heavy.

Carbide tipped tools give best service when rake angles and clearances are correctly ground. The following are suggested for single point tipped tools such as might be used for continuous turning in a lathe with the tool perpendicular to the work:

Material	Front Clearance (Deg.)	Side Clearance (Deg.)	Back Rake (Deg.)	Side Rake (Deg.)
Steel	6 to 8	6 to 8	0	3
Cast Iron	6 to 8	6 to 8	0 to 4	2 to 4
Copper	6 to 8	6 to 8	4	20
Brass	6 to 8	6 to 8	0	4
Bronze	6 to 8	6 to 8	0 to 4	4 to 8
Aluminum	6 to 8	6 to 8	10 to 20	10 to 20

These angles must be varied to fit the particular job being run, but the above can be used as a guide.

Rake reduces the cutting pressure, in addition to adding to the keenness of the cutting edge and facilitating chip removal. For cutting steel, when a chipbreaker is usually ground into the face of the tool, the carbide bit may be flush with the surface of the shank and the rake obtained with the chipbreaker. Negative rake angles have become more common in recent usage, especially for interrupted cuts, because they (1) permit the tool to take the starting load at a point back of the nose, giving wider distribution of the load; (2) absorb impact loads over a wider area at the seat in the tool shank; and (3) tend to push the chip, burnishing the surface of the work and producing a good surface finish. Keen cutting edges are used mostly for cutting soft materials such as aluminum. For steel cutting, the edges can be "dubbed" with a honing stone.

Shanks are usually made of high-carbon steel, and must be of such dimensions and so mounted as to reduce deflection to a minimum. Clearance and rake angle are milled from 2 to 5 deg. larger on the shank than those to be ground on the tip, so that only the tip need be ground after the carbide is brazed in position.

Carbide milling is an important method of metal removal, with a wide variety of methods of using the cemented carbide to obtain most economical and most effective service. Carbide blades can be fastened into the periphery or face of a milling cutter body, or carbide tips can be attached to shanks and the shanks held mechanically in the cutter. An economical form of milling cutter makes use of high strength cast iron for the body, with brazed-on carbide tips.

Milling with carbides involves an interrupted cut, and stresses in the carbide bit must be carefully considered. Negative rake angle is much used to effect better load distribution.

Drills and reamers are available in carbide tipped or, in some cases, in solid carbide types. Oil channels are provided in some of the carbide drills when desired.

The dimensions of carbide tips for cutting tools have been standardized by the Carbide Industries Standardization Committee, Malcolm F. Judkins, secretary.

Classification of Sintered Carbides

	Manufacturer's or Producer's Recommendation for Standard Grades								
	Carboloy	Carmet	Firthite	Kennametal	Talide	Teco	Vas. Ramet	Wesson	Willey
C-1	44A	CA 3	H	K-6	C-88 & C-89	A	2A68	GS	E-8
C-2	883	CA 4	HA	K-6	C-89 & C-91	A-1	2A5	GI	E-6
C-3	905	CA 7	HE	K-8	C-91 & C-93	469	2A7	GA	E-5
C-4	999	CA 8	HF	K-8	C-93	982	2A9	GF	E-3
C-5	78C	CA 5	T-83	K2S	S-88	CHD	EE	WS	710
C-6	78B	CA 1	TA	KM	S-90	C	EM	WM	710
C-7	78	CA 2	T-16	K3H	S-92	CF	E	WH	606
C-8	831	CA 6	T-31	K5H	S-92	CF	EH	—	509
C-9	883	CA 4	T-41	KE5 K138 KE7 K501 K6 K12	C-89	A-1	2A5	—	—
C-10	44A	CA 3	H	—	C-88	A	—	—	—
C-11	55A	—	HC	—	C-8815	B	—	—	E-12
C-12	—	—	T-32	—	C-8020	982	—	—	—
C-13	—	CA 12	DC-1	—	C-88	B	—	—	—
C-14	55A 55B 190	CA 10	DC-2	K-18 K-25	C-8815	B	2A3 2A15 2A20	—	E-25
C-15	—	CA 11	DC-3	—	C-8020	TH	—	—	—
C-16	—	CA 20	DC-4	—	C-7525	TH	—	—	E-25

Courtesy: General Motors Metallurgical Committee

NOTE: This chart presents the manufacturer's recommendations for carbides for the uses indicated. Classifications from C-9 through C-16 are in the formative stage and should be accepted as tentative only.

Here are the dimensions fixed upon for stock tips:

Thickness	Width	Length
1/16	1/8	5/8
1/16	3/16	1/4
1/16	1/4	5/16
3/32	3/16	5/16
3/32	1/4	3/8
3/32	1/4	1/2
3/32	5/16	3/8
3/32	3/8	3/8
3/32	3/8	1/2
3/32	7/16	1/2
1/8	3/16	3/4
1/8	1/4	1/2
1/8	1/4	5/8
1/8	1/4	3/4
1/8	5/16	7/16
1/8	5/16	1/2
1/8	5/16	5/8
1/8	3/8	1/2
1/8	3/8	3/4
1/8	1/2	1/2
1/8	1/2	3/4
1/8	3/4	3/4
5/32	3/8	9/16
5/32	3/8	3/4
5/32	5/8	5/8
3/16	5/16	7/16
3/16	5/16	5/8
3/16	3/8	1/2
3/16	3/8	5/8
3/16	3/8	3/4
3/16	7/16	5/8
3/16	7/16	13/16
3/16	1/2	1/2
3/16	1/2	3/4
3/16	3/4	3/4
1/4	3/8	9/16
1/4	3/8	3/4
1/4	7/16	5/8
1/4	1/2	3/4
1/4	9/16	1
1/4	5/8	5/8
1/4	3/4	3/4
1/4	3/4	1
5/16	7/16	5/8
5/16	7/16	15/16
5/16	1/2	3/4
5/16	1/2	1
5/16	5/8	1
5/16	3/4	3/4
5/16	3/4	1
5/16	3/4	1-1/4
3/8	1/2	1
3/8	3/4	1-1/4
3/8	3/4	1-1/2
1/2	3/4	1-1/4
1/2	3/4	1-1/2

Each of these sizes is made in several styles.

Carbide-tipped tools have been especially useful in the automatic screw machine, where long runs without resharpening will warrant payment of a premium price for tool material. The advantage is emphasized in the case of form tools, which usually require a special grinding set-up for resharpening.

The greater hardness of carbide cutting tools permits successful machining of harder materials. Steels hardened to about 325 to 360 Brinell can be cut with carbides, though cutting speeds must be reduced. Much harder steels have been machined at times, but such operations require care in the selection of the grade of carbide material and skill in operation of the machine. Some suggested cutting speeds as given by a leading carbide producer are as follows:

Hardness of Material Being Cut		Suggested Speed in Surface Feet per Min.
Rockwell "C"	Brinell	
25	249	300 to 400
30	276	220 to 300
35	323	150 to 220
40	370	100 to 150
45	427	80 to 100
50	495	60 to 80
55	545	50 to 60
60	601	30 to 50
65	682	20 to 30

Carbide cutting tools will show about 10 to 20 times the life of high-speed steel tools. While the carbide tools are more slightly difficult to sharpen, they need sharpening less frequently. Cost of the tool is about the same as for high-speed steel tools, and as they cut much faster, they can show a substantial saving for many types of machining.

Metalworking Dies

The very high resistance of cemented carbides to indentation and scratching makes them an excellent material for metalworking dies. Hardness alone does not indicate the fitness of a cemented carbide for die applications, however. Thus, for a deep drawing die a hardness of about 87.5 to 90 Rockwell A may be required, but for a cold heading die, where shock resistance is needed, a carbide of about 85 to 87 Rockwell A might be chosen.

The advantage in die life of carbides over other die materials is usually much greater than the corresponding increase in life in the case of cutting tools. There are cases in which carbide dies have run 150 times as long as the dies of other materials.

Carbide dies have taken over most of the work of the wire-drawing industry. Some of their advantages are:

(1) Many times longer life.
(2) Wires are drawn to closer tolerances.
(3) Wires have a better finish.
(4) Speed of drawing has been greatly increased.

Bars, tubing, and special shapes that formerly required machining can now be drawn accurately through carbide dies.

Dies for wire drawing are so well standardized that they can be bought as stock items for most sizes, and in rough, semifinished, or finished form. They may be tapered or cylindrical over the outside diameter of the nib, as the block may require.

Carbide dies are being used in increasing quantity for blanking, piercing, forming, and deep drawing all kinds of sheet metal. Plain carbon steel, alloy steels, stainless steels, brasses, bronzes, aluminum, and tin are being deep drawn on a production basis with carbide dies. What is perhaps the largest carbide die in a single piece used for deep drawing is a circular piece 24-in. inside dia. used for drawing the tops of milk cans in stainless steel. Another large single-piece die is used to draw washing machine tubs of hot-rolled steel. Carbide inserts at wear points are frequently used in the largest forming dies, such as those used in the automobile industry.

Drawing and forming dies of cemented carbides or with carbide inserts possess about the same advantages over dies of softer materials as do the carbide dies in wire drawing. They are:

(1) Much longer life; frequently 20 to 100 times the life of hardened tool steel dies.

(2) Reduced down time; polishing and repairs of worn dies are less frequent with the hard carbide material.

(3) Improved finish of the work. The cemented carbides show no tendency to weld or gall.

These add up to increased production and lowered costs.

A leading producer of carbide dies reports that users of carbide punching and blanking dies are obtaining an average of about 1,500,000 to 2,000,000 pieces between regrinds, as compared with an average of about 50,000 pieces with steel dies.

For punching abrasive materials, such as thermosetting plastics, carbide dies and punches repay their higher first cost very quickly. Silicon steel sheet for electric motor stators is also abrasive to tools, and these pieces are punched out with carbide punches and dies.

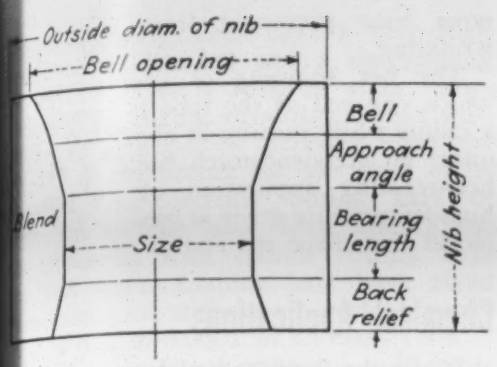
Cemented carbide dies are more difficult to fabricate than steel dies because of the extreme hardness of the material. The only forming processes that can be used are the molding of the powder, limited machining when necessary of the compact, and grinding, lapping and diamond boring of the sintered compact. The die must be designed so that it can be made by a combination of some or all of these methods. When a carbide nib is to be used, and the contours would be inaccessible for finishing, the nib may be made in sections.

When a carbide die is being designed to replace a steel die, it may duplicate the steel die. When the design is new, it is usually good practice to make a steel die first, to test it and make any changes necessary, then to duplicate the steel die in carbide.

Nibs for drawing round sections are usually made as one-piece rings, and irregular drawn sections usually require a segmented die nib.

Carbide die dimensions follow steel die practice in general. For small drawing dies having a radius instead of a bell, the draw radius is about four times the diameter of the stock, as with steel. The bearing length may be shorter in carbide dies than in steel, due to the greater resistance to wear in the former. Bearing length may be about 50% of the nominal die size (diameter at the bearing length) for copper and low-carbon steel wire, and about 66% of size for high-carbon steel. For many applications the bearing length may be still further reduced, thus lowering the cost of the die. Back relief is important, and should be made large to lessen any tendency to flaking at the exit end of the bearing length. It may be about 15% of nib height.

For blanking, piercing, forming and deep drawing the carbide nib is of a grade having higher impact resistance, and must be designed for more rigid attachment to the die block. Methods of attaching carbide sections will be discussed later.



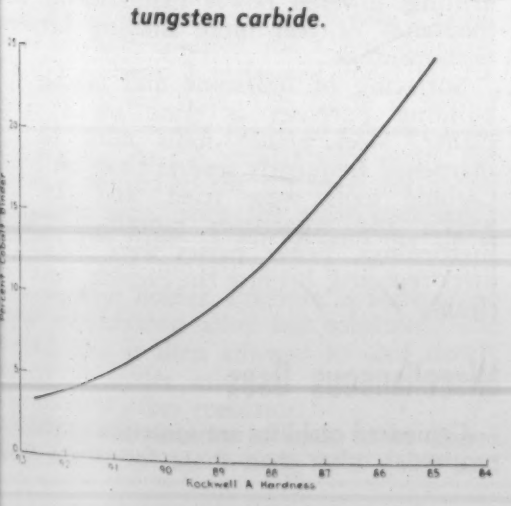
A typical wire drawing die made from cemented carbides.

Blanking dies of carbide materials usually run 20 to 40 times as long as steel dies, producing clean-cut pieces of work. While the hard die material shows its greatest superiority in blanking and piercing abrasive stock, it shows gains in the number of perfect pieces produced without regrinds in soft and non-abrasive materials also. The hardness of the cemented carbide permits it to retain its shearing edge many times as long as tool steel. In addition, less stock need be removed to sharpen the carbide.

As with steel dies, the punch governs the size of the hole in a piercing operation, and clearance must be added to the die opening. The same clearance as for steel dies is suitable for carbide work. For blanking, the die opening controls the size of the work, and clearance is subtracted from the punch dimensions. The carbide nib must be of sufficient depth for the production required, with a minimum depth of ½ in. plus 0.005 in. for each regrind expected to be made.

Drawing of sheet metal is another field in which carbide dies have won a place by production economies. The nongalling quality of cemented carbides in contact with metals being formed makes carbide draw rings a money-saver in terms of production and also a means of reducing polishing and buffing of the finished piece to obtain a mirror finish. This is an advantage especially valuable in the case of stainless steel. There have been cases in which a single set of carbide dies has completed an entire run of 8,000,000 stainless steel parts without servicing the dies. In another case laminations for electric motors were punched from sheet steel, with a steel punch and die set giving 150,000 before regrinding, and a carbide set running 4,000,000 to 5,000,000 pieces between grinds.

Variation in Rockwell A hardness with increasing percentages of cobalt binder in tungsten carbide.



Wear Resistance Applications

A field of use for cemented carbides that is already large utilizes its combination of indentation and scratch hardness to provide resistance to wear. The carbide industry anticipates that this will grow into the largest field of carbide applications as design and finishing techniques become better understood by prospective users, and the advantages to be gained through the use of carbides are more fully realized. Parts made entirely of carbides, or with shaped inserts at points of wear, often have a useful life 100 times that of parts made of softer materials.

Applications of cemented carbides for wear resistance are so diverse that they cannot be conveniently classified. The examples given are intended to illustrate this diversity.

Brick mold liners—In the manufacture of firebrick the material, which includes such abrasive ingredients as silica, alundum, carborundum, and magnesite, is squeezed into molds before firing in a kiln. Four molds comprise a set. Each mold was lined with hardened steel plates to withstand the abrasive action of the pasty brick material as it is squeezed in from overhead, then pressed to final form by one stroke of a ram.

The steel liners required regrinding or replacement after about 8000 to 10,000 silica bricks were molded, and changing liners required one full shift. Slabs of cemented carbide were placed in each mold as liners, two side pieces 9⅝ in. by 6⅛ in. by ⅜ in. and two end pieces 4 9/16 in. by 6⅛ in. by ⅜ in. completing the set. As the side pieces weighed about 12 lb. each and the end pieces about 5 lb. each, about 136 lb. of carbide was used in each set. The plant then started a run of 42,000 silica bricks. The carbide liners not only completed the entire run, but when examined at the end of the run the finish grinding lines were still visible on the surfaces of the hard material. In addition to saving the maintenance and repair costs of the steel liners, about four days of production time was saved by avoiding the change of liners during the entire run.

Centerless grinder rests—Rests on centerless grinders have made use of carbide strips, brazed to the rest, to reduce wear. The strips may be from one to four in number, and are generally from 4 in. to 9 in. long, though pieces as long as 36 in. have been used.

In a typical case, where high-speed steel rests had been given about 1,600 pieces of work per grind, the brazed-on carbide strips lasted for 575,000 pieces before grinding became necessary.

Crimping rolls—Double seaming rolls, about 5 in. in dia., crimp or roll the bead at the top of a pail or can. Use of a carbide ring, made in one piece and mechanically held in a steel body with a steel clamping ring, is now being used for the wear surface on each roll. It lasts many times as long as the solid steel rolls.

Rest for thread roller—Rolling threads in a steel blank, SAE 4140, is one of the jobs done on a circular thread roller. Rotation of the steel blanks quickly wore the cast iron guide rest, making it necessary to regrind the rest about once each 8 hr., after about 9000 pieces had been handled. After each grinding shims were required to raise the guide to the proper height. The accumulated shims soon made the guide unsteady, and it was then necessary to install a new guide rest in the machine.

Another fault that sometimes occurred was the scoring of the guide rest by a defect in the tops of the rolled threads. A regrind was necessary to remove these scratches also.

The guide rest was surfaced with cemented carbide, and the number of pieces that could be processed before grinding increased to an average of about 74,000. Regrinding itself was simpler, as only about 0.001 in. had to be removed from the surface, making the readjustment much easier. Scored threads no longer marked the surface of the rest, eliminating that problem entirely.

Roller turner rolls—In the pins and rollers of steady-rests and guides for long work pieces being machined in lathes or automatic machines, uniformity of wear is as important as the amount of wear. Tool steel, and in some cases high-speed steel, have been used in these rolls. The rolls were made of solid cemented carbide, and the life of the parts was increased about 400 times.

Collets—Wartime experience in machining SAE 6310 bar stock in Swiss-type automatic screw machines indicates that use of carbide-lined collets greatly increases the length of run on the machines before adjustment of the collets becomes necessary.

Stops—The stops on automatic screw-machines can be protected with pads of carbide to increase their accuracy-life. Small pieces of carbide, usually standard tool tips, are brazed to the stops.

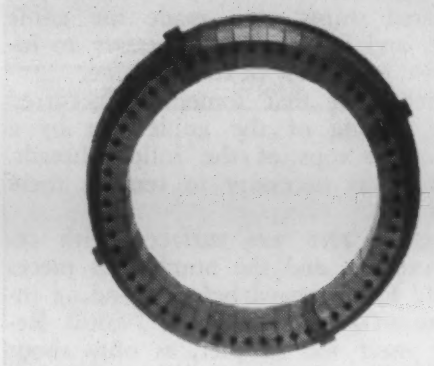
Lathe and grinder centers — Carbide-tipped lathe and grinder centers have become a standard item with a record of success extending over a number of years. Small centers are usually solid cones of carbide brazed to steel shanks, but the larger pieces are built up by strips of carbide brazed to the steel portion.

Production experience shows that carbide centers can withstand more pressure than steel centers without danger of burning. In production work a light finish grind each month keeps them in good shape, while for general work centers are ground once every seven or eight months.

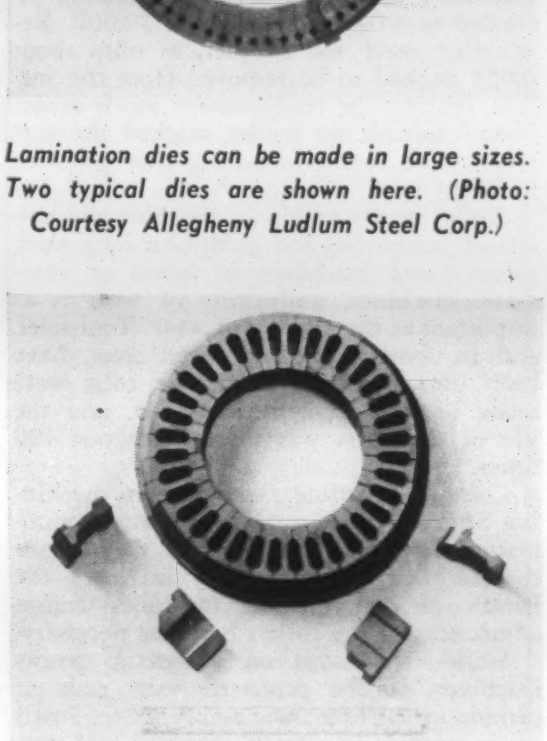
Rivet spinner—Spinning of small rivets in brass, gold and stainless steel requires good finish on the work, as these rivets go into watch bracelets and other jewelry. A hardened steel tool was used to form the button head on the rivet as the tool rotates at high speed. A solid carbide tool was tried, and showed 300 times the service life of the steel spinning tool, with improved finish.

Burnishing bar—Extreme wear is the problem when a burnishing bar is used to improve the finish of piston pin holes in cast iron pistons. Chromium-plated burnishers lasted for only 50 to 100 pieces. A solid carbide bar ½ in. in dia. and about 1¼ in. long burnished more than 5000 piston pin holes without requiring maintenance, after which the user stopped keeping performance records. The carbide bar gave a higher polish to the metal surface than the other burnishing tools.

Beading roll—A beading roll turns the edges of iron and steel tubs to form the top bead. Hardened tool steel rolls wore away 0.008 in. in the beading of 25,000 tubs of 26-gage stainless steel, and had to be



Lamination dies can be made in large sizes. Two typical dies are shown here. (Photo: Courtesy Allegheny Ludlum Steel Corp.)



completely resurfaced. Solid carbide beading rolls were tried, and showed no detectable wear after beading 25,000 stainless steel tubs. The same rolls were continued in service while 75,000 iron tubs were made, and at the end of the entire run the rolls still showed no appreciable wear.

Rod coating extruding die—The coating applied to coated welding rod contains highly abrasive minerals, and these rapidly wear the die through which the coating is extruded over the rod. Steel dies and rod guides made to a hardness of Rockwell 64C lasted for about two weeks under average working conditions, one manufacturer reported. Carbide dies and guides were installed. When results were reported the new dies and guides had been in use 24 hr. a day for seven weeks, with no signs of wear. Based upon the performance to date, it was estimated that the life of dies and guides will be about 40 weeks, affording continuous production over that entire time.

Guide rings—Carbide guide rings have been installed in a Mosspeed braider, guiding the threads of nylon and hard twisted raw silk as it passes at high speed from the spindles. They are reported to be lasting about 100 times as long as hardened steel guides.

Of a similar nature is the use of carbide guide pins, 1⅝ in. long and 3/32 in. in dia., used in pairs and fastened into a plastics block to form a "V" which acts as a guide. These guide pins have a record of four years of continuous operation to date.

Feed rolls—Carbide rolls are used on the automatic feed of an automatic screw machine to replace the steel rolls formerly operating. A V-type roll 2⅛ in. in dia. and 1⅛ in. wide has a steel hub in which a keyway and a tapped hole for a setscrew have been cut. Two sizes of flat rolls in carbide were used, one 2⅜ in. in dia. and ¾ in. wide, the other 2⅛ in. in dia. and ¾ in. wide. Bar stock fed to the machine ranges from 5/32 in. to 1 in. in dia.

Steel rolls required reconditioning after about 4700 linear feet of stock had been run, on an average. The minimum time for reconditioning and setting up the steel rolls was 1 hr. The carbide rolls had been in service for one year when examined, and had handled 50,300 linear feet of stock. They showed no signs of wear, and have not yet been given any reconditioning.

High Temperature Applications

A new high-temperature cemented carbide has been announced recently, along with limited information about its applications and properties, but enough has been made public to show that it may revise some ideas about the high-temperature possibilities of cemented carbides. In general, however, it remains true that the standard grades of carbide formulations are not primarily high-temperature materials. The cobalt binder, and probably tungsten carbide itself, tend to oxidize and to disintegrate when exposed to high temperatures in an oxidizing atmosphere for a prolonged period.

When high hardness combined with fair resistance to temperatures up to about 1500 F is required, cemented carbides may be considered. If the application does not involve continuous heating at the top temperature, and if the atmosphere will be noncorrosive and neutral or reducing, carbides will do better than if conditions were otherwise. As the carbides do not obtain their hardness through heat treatment, they do not soften when repeatedly heated and cooled.

The titanium carbide combination given in the list of carbide formulations as a high-temperature material is probably the only carbide material intended specifically for high-temperature service. It may be pure titanium carbide plus binder, or may contain small quantities of other carbides to increase resistance to oxidation. It usually has a rather coarse grain size. While applications have not yet been well developed, the material has been used experimentally for gas turbine parts to operate at high temperatures. It has also found use in brazing jigs and fixtures, and in the manufacture of support pins for porcelain enamel ware in the firing ovens. These pins have a life of about six weeks as compared to 10 hr. for cast nickel-chromium alloy pins.

Quenching blocks are used for chilling very thin strip steel, such as safety razor blade stock. In a typical application three cemented carbide blocks 1 11/16 in. wide and 3/16 in. thick are placed together end-to-end to form a set 13 in. long, and are mechanically attached to cast iron or brass water cooling jackets. Two sets of the water-cooled carbide blocks are pressed together as the heated safety razor blade stock passes between them. What results is a pressure quench of the strip steel, with a certain degree of atmospheric control added by the close proximity of the work and the quench blocks. The steel is quenched and at the same time prevented from warping or wrinkling.

The hot spinning of steel tubing, in which one end of the tube is formed in a radius while turning at about 600 r.p.m. under an acetylene torch flame, is another heat-resisting application of carbides. A high-temperature grade is used for the form blocks that shape the end of the pipe.

Chemical Applications

While the carbide particles are quite inert chemically, the cobalt binder in the sintered compact is subject to chemical attack by some acids. Even cold dilute acids can attack the metal, and elevated temperatures with higher-strength acids will destroy it quickly. A special grade of cemented carbide using platinum as a binder has been used where chemical attack would destroy the less resistant binder.

This grade of cemented carbide is used for centrifuge nozzles in contact with corrosive chemicals, for valve tips and inserts for rotary seals, and similar applications requiring both resistance to chemical attack and high hardness or wear resistance.

Where no unusually corrosive conditions are to be encountered, the standard grades of cemented carbide will generally be satisfactory.

Mining Equipment

Such items of mining equipment as rock drills and coal cutter bits must withstand extremely severe abrasion and hard usage. Before the advent of cemented carbides, diamond drills had been the only material that would actually cut hard rock. Steel drills were intended only for crushing the rock against which they were used. It was natural that cemented carbides should be considered for this difficult work.

While carbides are thought of as rather brittle materials, they have been used successfully for tipping rock drills, taking up to 2000 blows a minute without failure when properly supported in the drill. Results in the field show that carbide-tipped drills can drill up to 125 times the depth of hole sunk with the conventional steel drills before resharpening.

Drag and core bits tipped with carbide are used, frequently in conjunction with diamond drills, in the hardest rock. Of the same type are masonry drills, used for drilling building block, brick, stone and slate.

Rotary drills for both rock and coal make use of two- and three-prong bits with cemented carbide inserts. Users report faster drilling, lowered power requirements, and thousands of feet more drilling between resharpenings.

Surfacing of limestone and marble for building purposes is done on a stone planer. Steel planer tools must be resharpened frequently several times an hour. Carbide tools were tried, and ran for weeks, and sometimes months, between sharpenings. Fewer passes were necessary, users reported, because the carbide tools cut cleaner.

Miscellaneous Uses

Cemented carbides are sometimes used for properties other than those for which they

best known. They have a very high modulus of elasticity, and a use gaining in importance as it achieves wider recognition is one taking advantage of this stiffness. Precision boring depends upon the rigidity of the boring bar for much of its accuracy, and recently boring bars of cemented carbide have been finding use in connection with carbide cutting tools for this work. Carbide bars have about three times the stiffness of steel. Accuracy may be held to 0.0001 in. in many cases.

Grinding quills of cemented carbide are used similarly.

Rolling of very thin sheets of steel and other metals has made use of carbide rolls. A pair of carbide rolls, each made in a single section, and weighing about 12 lb. each, are backed up by several sets of conventional steel rolls in a typical installation.

A machining scheme for broaching automotive main bearings makes use of a carbide broach for the machining and a carbide lining for the broach blocks that hold the work. The bearings are made of a steel-backed silver alloy, and must be held to very close tolerances. Steel broach blocks wore out rapidly, making it difficult to hold tolerances on a long run. The carbide blocks hold tolerances more than 100 times as long as did the steel.

Manufacturers of sanitary cans use a "tin slitter" to cut the tinned steel sheet into strips for fabricating into cans. A number of sharp rings, each 7 in. in dia., are spaced so that the sheet will be slit into strips of the proper width. The ring cutters are now being tried in cemented carbide, and results indicate that they will far outperform steel cutters.

When teeth are cut in steel files with a steel chisel, the 1.25% carbon steel in the file quickly dulls the chisel. A chisel cuts one tooth per blow, striking about 600 blows per 10-in. file. After cutting about eight dozen files, the chisel dulls to such a point that it must be reground or the files cut thereafter must be graded below "Class A." Carbide chisels were tried, and now regularly produce 152 dozen files of "Class A" quality before requiring regrinding.

Cemented carbides have a rather low electrical conductivity, but they have found a use in contacts for telegraphic apparatus. Modern telegraphic equipment runs at high speed, and the metals formerly entirely satisfactory, such as silver, platinum and platinum-iridium, sometimes tend to stick unless cleaned every day. Carbide contacts are nonwelding and self-cleaning, and are reported to be giving materially better service in several installations.

Cemented carbides are being used to make a few hand tools, such as deburring files and scribers. Files are usually made with toothed carbide slabs attached to the faces of flat steel. Scribers have brazed-on carbide points. Center punches, paint scrapers, dental drills, knife sharpeners, sharpening devices for scissors, lawn mower sharpeners are other small tools utilizing cemented carbides.

Carbide-tipped mattress needles have proved their right to a place in the tool room of a large mattress manufacturer. Steel needles used to sew the beading around a mattress would require resharpening after sewing halfway around one, and resharpening required about one-third as much time as sewing a mattress. Carbide-tipped needles now sew 600 mattresses before the points need resharpening. In addition to the saving in time, the cost of needles has been cut, as a steel needle had to be discarded after 15 sharpenings.

Attaching Carbides to Tools

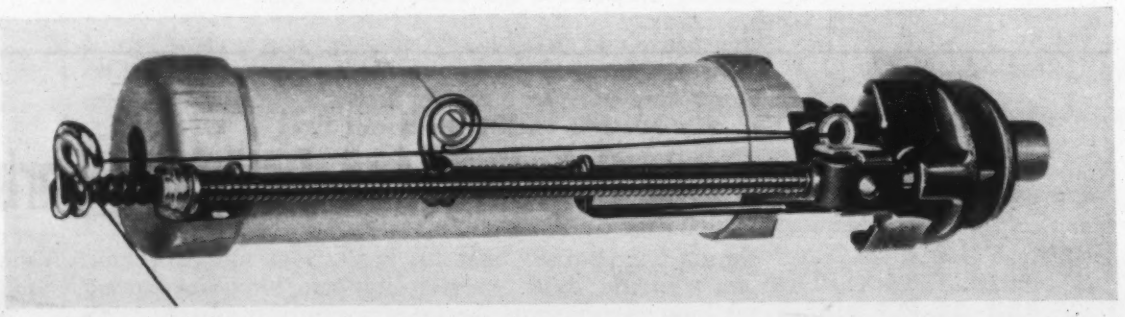
Carbide tips are usually attached to cutting tools by brazing. A silver brazing compound that will fuse at 1300 to 1400 F, a cherry red heat, will have good strength and good wetting properties, and is recommended by most carbide manufacturers. Copper brazing, or brazing with any of a number of the lower-melting brazing alloys, such as tobin bronze, will give satisfactory results, however.

Torch brazing is frequently used in the small shop, or where there are only a few tips to be attached. After the recess has been cut in the steel shank with a side or end mill the tip, shank recess, and pieces of brazing alloy cut to fit the recess are thoroughly cleaned with carbon tetrachloride to remove any traces of grease. The parts are then painted with a coating of a good borax flux, in either powder or paste form, fasten the steel shank in a vise or other suitable holder, and place the pieces of brazing alloy and the carbide tip in the recess.

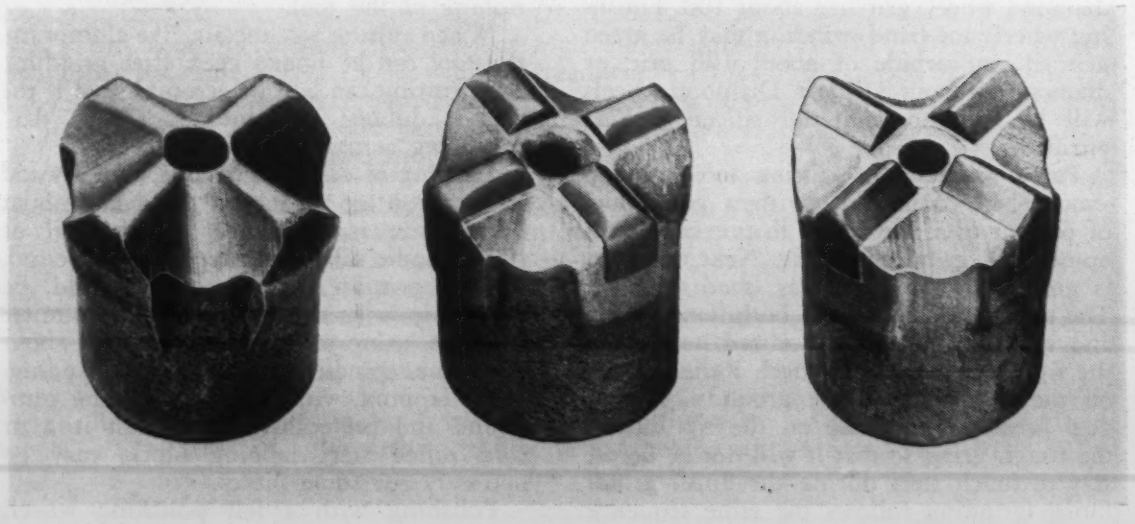
Using an oxyacetylene torch with a fairly large tip and adjusted for a nonoxidizing flame, the shank is preheated under the tip to a cherry red heat. The flame is played over the end of the shank to prevent local overheating, As the brazing alloy melts, the flame is shifted to the tip itself for a few moments, then, with the alloy completely molten, the flame is cut off and the tip is firmly pressed into the recess with a notched rod or other holder. Pressure is maintained until the brazing alloy has solidified. The tipped tool is then allowed to cool slowly in air or under asbestos, lime, powdered charcoal, or other insulator.

Where the number of tools to be tipped justifies it, furnace brazing is a quick and efficient method of attaching carbide tool tips. The furnace is set for about 1500 to 1600 F, the tool shank, carbide tip and brazing alloy are cleaned and placed together as before, and the pieces are held together by loops of nichrome wire, using four or five separate loops and drawing up tightly with a pair of pliers. The assembly is then placed in the furnace for a time determined by test, and after fusion of the alloy, is removed and cooled as before.

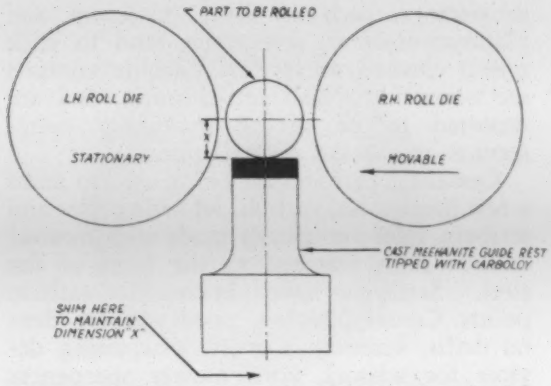
Copper brazing is best done in a furnace,



Carbide rings lead nylon and silk threads by the nose. (Photo: Courtesy Carboloy Co.)



Carbide rock drills wear slowly, drill deep. (Photo: Courtesy Carboloy Co.)



Sketch of thread roll rest that is tipped with tungsten carbide. (Courtesy: Carboloy Co.)

but temperature must be carried to about 2200 F to insure free flowing of the copper. A nonoxidizing atmosphere should be maintained in the furnace.

The simplest and fastest means of attaching carbide tips is by induction brazing. Shank, tip and alloy, prepared as before, are placed together and the tip end of the tool is held in the coil of an induction heater for a predetermined time. The tool is then removed from the coil, the tip held in position until the brazing alloy hardens, and the whole is air cooled.

For some types of cutting tools, especially those for heavy duty, the preference is for mechanically held carbide tips. In this case the tool is designed so that screws, clamps or wedges hold the carbide firmly and evenly in a carefully formed recess. Some of the advantages claimed for mechanically-held carbide tips are:

(1) The assembly is stress-free. (Thermal expansion of carbides is about one-half that of steel.)

(2) Deterioration due to exposure to elevated temperatures is avoided.

(3) Danger of ineffective bonding, not discernable by visual inspection, is eliminated.

(4) Loss of carbides through heat cracks in the assembled tool, either just after brazing or upon beginning a cut, is avoided.

(5) In many mechanically-held assemblies, the carbide may be easily replaced or adjusted.

In the case of dies and many similar applications in which carbide inserts are used, the choice must be made among shrinking, pressing, or mechanical holding of the carbide. For most die work, shrinking the case over the nib is the preferred method, as it gives the carbide nib the greatest amount of support. The case is usually made of SAE 4340 steel, hardened to about 38 to 42 Rockwell C. It is good practice to make the inside diameter of the case to accommodate the nib, making shrink allowance here.

Shrink allowances may be as follows:

Outside Dia. of Nib	Shrink Allowance
From 0.437 to 0.562 in.	0.0013-0.0018 in.
From 0.562 to 0.687 in.	0.0016-0.0021 in.
From 0.687 to 0.812 in.	0.0021-0.0026 in.
From 0.812 to 0.937 in.	0.0025-0.0030 in.
From 0.937 to 1.125 in.	0.0028-0.0033 in.
From 1.125 to 1.375 in.	0.0035-0.0045 in.
From 1.375 to 1.750 in.	0.0038-0.0048 in.
From 1.750 to 2.000 in.	0.0043-0.0053 in.
From 2.000 to 3.000 in.	0.0045-0.0055 in.
From 3.000 to 3.500 in.	0.0055-0.0065 in.
From 3.500 to 4.000 in.	0.0065-0.0075 in.
From 4.000 to 5.000 in.	0.007 -0.008 in.
From 5.000 to 6.000 in.	0.008 -0.009 in.
From 6.000 to 7.000 in.	0.009 -0.010 in.

The case should fit the nib snugly, as otherwise the lack of support will greatly increase danger of cracking the carbide. Service conditions must be considered also. In one instance of die failure the carbide nib cracked because the die became heated to 300 F in service, and the case shrank away from the nib.

When shrinking is impossible or impracticable, the nib may be pressed into the steel case. Press fit allowances may be the same as for shrinking. Pressing does not give the same assurance of proper support as shrinking, however.

Dies and other pieces of equipment sometimes use small carbide inserts of such a shape, or held in such a manner, that neither shrinking nor pressing can be used for assembly. Mechanical fastening by the use of screws, usually operating into blind tapped inserts in the carbide section, is the method used by one manufacturer for attaching. Carbide inserts in large die sections at wear points are usually fastened this way. It is important that the recess be accurately machined so that adequate support is given to the carbide.

When a blind tapped insert in the carbide is not desirable, a counterbored hole preformed in the carbide nib will accommodate a cap screw. Another method is to put a threaded section into a counterbored hole through the carbide, and to attach by a screw through the steel case. For both of these types of mechanical attaching a hole will appear in the face of the carbide insert.

Carbide nibs in such dies as wire drawing dies require repolishing occasionally, and the steel case should be given relief at the exit end of the nib. This will permit polishing the carbide nib with diamond dust and avoid contact of the steel with the abrasive.

Die nibs may sometimes be held in place by steel rings or other clamps, bearing against a shoulder on the nib and screwed into the steel die case.

Grinding and Polishing Carbides

Rough grinding of carbides can be done on a green grit silicon carbide or an alundum wheel, grit size about 60, or on a diamond wheel, grit size about 100. Finishing wheels for hand grinding may be green grit silicon carbide of about 100 grit, or diamond of about 220 grit. Diamond wheels will be resin-bonded, and silicon carbide vitrified.

For a single-point cutting tool the top should be ground first, with a good flow of coolant over the wheel to prevent development of grinding cracks. Next, the end is ground in the same way, then the side. The tool should be moved both horizontally and vertically to avoid localized heating of the tip or wear on the wheel. Relief angles on the shank should be ground 2- to 4-deg. greater than those on the tip during the rough grind so that it will not be necessary to touch steel during the finish grind. Finish grinding follows the same sequence as rough grinding, with the table set at the angles desired for relief.

Machine grinding usually uses diamond wheels of the grits given. Machine grinding gives better control over angles and positioning of the tool.

When cutting soft metals, like aluminum, the tool can be honed keen after grinding. Steel cutting can best be accomplished if the tool is dubbed by honing a slight "flat" of 45 deg. across the cutting edge.

Lapping of dies is best done with a wood or cast iron lap. Diamond powder of about No. 4 size is suspended in olive oil or light spindle oil for the lapping compound. Where possible, the carbide should be lapped in a grinding machine or similar machine, using medium pressure and about the same spindle speeds as for grinding. Hand lapping, with the same lapping compound and preferably with a cast iron or cold rolled steel lapping block, may be necessary for some pieces.

Polishing with a felt polishing wheel, using No. 5 or No. 6 diamond powder in oil, will impart a high finish to the carbide surfaces. A wad of cotton wool wrapped around a stick will make an efficient improvised polishing device, or will answer for polishing internal surfaces of dies too small to admit the felt wheel. Speeds should be considerably slower than for grinding—about 1500 surface ft. per min.

Carbide dies work best and give the longest useful service when polished to a high finish.

The following companies and organizations contributed information for this manual either through their personnel or by means of bulletins or published data:

American Society of Tool Engineers, Detroit, Mich.

Carboloy Co., Inc., Detroit, Mich.

Carbide Alloys Div., Allegheny Ludlum Steel Corp., Detroit, Mich.

Firth Sterling Steel & Carbide Corp., McKeesport, Pa.

Kennametal, Inc., Latrobe, Pa.

Metal Carbides Corp., Youngstown, Ohio

Vascaloy-Ramet Corp., North Chicago, Ill.

Materials Engineering File Facts

NUMBER 172
February, 1949

Comparison of Common Aluminum Casting Alloys

Alloy Classification	Composition-Nominal	Type of Casting	Characteristics and Uses	Standard Specifications
Aluminum-Silicon	5% silicon	Sand	Easy to handle in foundry; when molten has high fluidity; used for intricate and/or pressure-tight castings	ASTM B26-47T, Alloys S1 and S2; SAE 35
		Permanent mold	For general use; cooking utensils made of the more closely controlled compositions because of their corrosion resistance	ASTM B108-47T, Alloys S1 and S2
		Die casting	Resistant to salt water corrosion; used for marine fittings; (the alloys of this composition all have excellent corrosion resistance, are not hot short, have low tensile and yield strengths coupled with good ductility; machinability is fair and they do not respond to heat treatment)	ASTM B85-46T, Alloy S4; SAE 304
	7.5% silicon plus magnesium	Sand and permanent mold	Corrosion resistance and castability comparable to those of the 5% silicon alloys; heat treating improves physical properties over those of the 5% silicon alloys; machinability is good; these are general purpose alloys	ASTM B26-47T, Alloy SG1; ASTM B108-47T, Alloy SG1; AMS 4217, AMS 4284, SAE 323
	10% silicon plus magnesium	Die casting	Often used to replace 12% silicon alloys as it is easier to die cast	ASTM B85-46T, Alloys SG2 and SG3
	12% silicon	Die casting	Used for complicated and/or thin walled castings because of its superior castability; also has excellent resistance to salt water corrosion and freedom from hot shortness	ASTM B85-46T, Alloys S5 and S9; SAE 305; AMS 4290
	12% silicon plus nickel	Permanent mold	Has low coefficient of thermal expansion, high resistance to wear, good mechanical properties at elevated temperatures; can be heat treated; used for automotive pistons	ASTM B108-47T, Alloy SN41; SAE 321
Aluminum-Copper	4.5% copper	Sand	Very hot short and can only be sand cast; one of the oldest high-strength, heat treatable alloys; physical properties can be altered by variations in heat treatment; used where combination of high strength, ductility and lightness is needed (such as in parts for internal combustion engines, automobiles and trucks, outboard motors and other marine applications)	ASTM B26-47T, Alloy C1; SAE 38; AMS 4231
	4% copper plus magnesium and nickel	Sand and permanent mold	Somewhat hot short, used for sand castings and simple permanent mold castings; possesses high physicals and good bearing qualities at elevated temperatures; used for pistons, air cooled cylinder heads, valve guides, etc.; generally used in heat treated condition; has good machinability	ASTM B26-47T, Alloy CN21; ASTM B108-47T, Alloy CN 21; SAE 39; AMS 4220; AMS 4222
	10% copper plus silicon and magnesium	Sand and permanent mold	Has good mechanical properties at high temperatures; has poor castability; responds to heat treatment; used for pistons, cylinder heads, piston sleeves, valve guides, camshaft bearings and other parts requiring high hardness and strength at elevated temperatures	ASTM B26-47T, Alloy CG1; ASTM B108-47T, Alloy CG1; SAE 34
Aluminum-Magnesium	4% magnesium	Sand	Has very good machinability and highest corrosion resistance of all commercial aluminum alloys; has poor castability and will not respond to heat treatment; used for cooking utensils, food handling equipment, carburetor cases and cast pipe fittings where corrosion resistance, pleasing color, ability to take a high polish, and average mechanical properties are desired	ASTM B26-47T, Alloy G1; SAE 320
	4% magnesium plus silicon	Sand and permanent mold	Resistant to tarnishing and has better castability than 4% magnesium alloy; machinability is excellent, does not respond to heat treatment; used for pipe fittings and cooking utensils	ASTM B26-47T, Alloy GS1; ASTM B108-47T, Alloy GS1
	4% magnesium plus zinc	Permanent mold	Castability is improved over that of 4% magnesium alloy; corrosion resistance and machinability are excellent; used as cast	ASTM B108-47T, Alloy GZ1

(Continued on page 87)

Photos courtesy Ford Motor Company

KAOCAST

CAR TOP Tops them all

Faced with the need of producing thousands of pressed shapes in its small tunnel kiln, the Ceramics Laboratory of the Ford Motor Company encountered severe disintegration of car top refractories because of rapid temperature changes — from room temperature to 2300 F and back again in two hours.

A variety of refractory materials were tried—some very costly—but all failed after 20 to 44 cycles through spalling and cracking.

Then car tops were cast in three sections with KAOCAST. **These car tops went through 118 cycles and are still as good as new. The KAOCAST showed no signs of shrinkage, expansion, distortion, cracks or spalling.**

And, the perfection of the castings was astonishing . . . yet they were made quickly and easily by ordinary shop methods.

Perhaps you, too, have a problem in shapes, car tops or furnace linings which can be solved quickly and economically through the use of KAOCAST. Your local B&W Refractories Engineer will be pleased to supply data on this unusual refractory castable.

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Materials Engineering File Facts

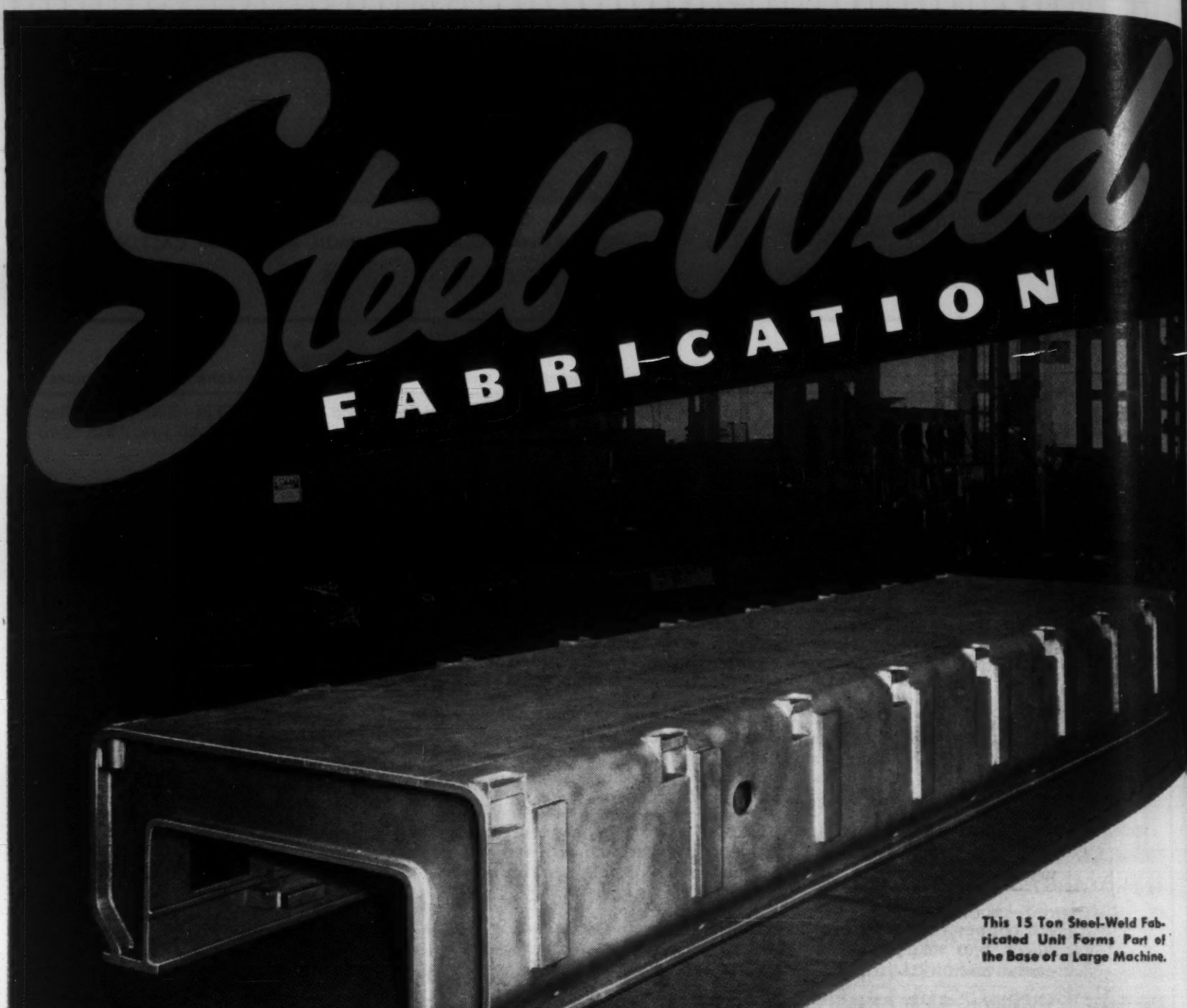
NUMBER 172 (Continued)

COMPARISON OF COMMON ALUMINUM CASTING ALLOYS

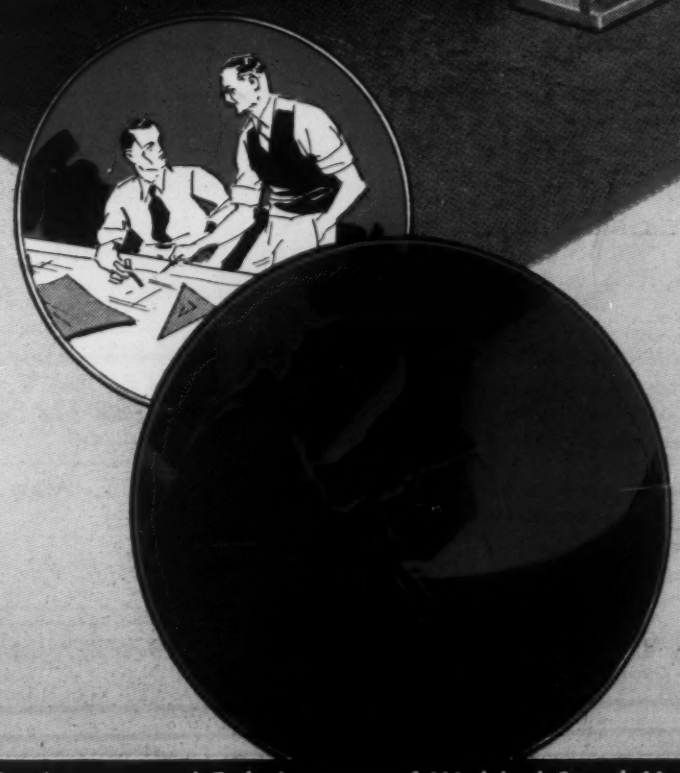
Alloy Classification	Composition-Nominal	Type of Casting	Characteristics and Uses	Standard Specifications
Aluminum-Magnesium	10% magnesium	Sand	Combines high strength and elongation with good shock and corrosion resistance; used only in heat treated condition; not used at service temperatures much above 200 F; special foundry practice needed as its castability is only fair; used for structural parts in aircraft, railway equipment, trucks and buses, etc.	ASTM B26-47T, Alloy G3; SAE 324; AMS 4240
Aluminum-Copper-Silicon	4.5 copper, 1.5-2.5% silicon	Sand	Combines fair strength and corrosion resistance with good machinability and castability; generally used as cast; a general purpose alloy	ASTM B26-47T, Alloy CS5; SAE 325; SAE 326
		Permanent mold	Has good corrosion resistance, castability and machinability; responsive to heat treatment; used as a general purpose alloy where high strength and ductility are required	ASTM B108-47T, Alloy CS4; AMS 4282; SAE 380
	7.5 copper, 2.5% silicon plus zinc	Sand and permanent mold	Can easily be made from scrap; combines fair corrosion resistance, very good castability and excellent machinability; generally used as cast (sometimes castings are annealed); used for a variety of automotive parts, washing machine agitators, etc.	ASTM B26-47T, Alloy CS22; ASTM B108-47T, Alloy CS22; SAE 33
	7 copper, 5.5% silicon plus magnesium and zinc	Permanent mold	Can be made from scrap; has good castability and machinability; corrosion resistance is fair; generally given a stabilizing (or aging) heat treatment; used largely for automotive pistons	ASTM B108-47T, Alloy CS23; SAE 300
	10 copper, 4% silicon plus magnesium and nickel	Permanent mold	Has fair corrosion resistance, good castability and very good machinability; thermal expansion is low; used for pistons and for flat iron sole plates	ASTM B108-47T, Alloy CS21
Aluminum-Silicon-Copper	5.5 silicon, 4.5% copper plus zinc	Sand and permanent mold	General purpose alloy having all-round characteristics; heat treatable	ASTM B26-47T, Alloy SC8; ASTM B108-47T, Alloy SC8
	5.5 silicon, 4.5% copper	Permanent mold	A general purpose alloy; has excellent castability, fair corrosion resistance and good machinability; used as cast	ASTM B108-47T, Alloy SC1
	5 silicon, 3.5% copper plus zinc	Die casting	A cheap, general purpose alloy suitable for simple castings; corrosion resistance is fair	ASTM B85-46T, Alloys SC2 and SC5; SAE 307
	8.5 silicon, 3.5% copper, plus zinc and nickel	Die casting	Castability is improved over that of 5 silicon, 3.5% copper plus zinc alloys; can be made from scrap; alloy SC 6 (SAE 306) is used in cold-chamber die casting machines; alloy SC7 (SAE 308) is suited to use in gooseneck machines	ASTM B85-46T, Alloys SC6 and SC7; SAE 306; SAE 308, AMS 4291
	5 silicon, 1% copper plus magnesium	Sand and permanent mold	Excellent castability, good corrosion resistance and machinability; heat treatable; used for liquid cooled cylinder heads and other applications where intricate, sound, high strength (at elevated temperatures) castings are needed	ASTM B26-47T, Alloy SC21; ASTM B108-47T, Alloy SC21; SAE 322
	8 silicon, 1.5% copper plus manganese, magnesium, zinc, chromium and nickel	Sand	Has excellent castability, good corrosion resistance and machinability; responsive to heat treatment; used for diesel and gasoline engine parts	ASTM B26-47T, Alloy SC42
	12 silicon, 1.5% copper plus manganese, magnesium and zinc	Permanent mold	Machinability and castability are fair; has good corrosion resistance and is heat treatable; used for pistons	ASTM B108-47T, Alloy SC41
Aluminum-Zinc-Magnesium	8% zinc plus magnesium and copper, 5.5% zinc plus magnesium, titanium and chromium, 4 zinc, 2% magnesium, plus manganese and chromium	Sand and permanent mold	This is a relatively new group of alloys possessing high dimensional stability and high physical properties without heat treatment (the 4 zinc, 2% magnesium alloy can have its physicals improved by heat treatment); these are premium priced alloys, very sensitive to contamination by silicon; machinability is generally excellent; the 5.5% zinc alloy remains very ductile (permitting severe cold working) for about two weeks after casting (unless aged artificially)	ASTM B26-47T, Alloy ZG41; SAE 310

Steel-Weld

FABRICATION



This 15 Ton Steel-Weld Fabricated Unit Forms Part of the Base of a Large Machine.



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MATERIALS & METHODS

DIGEST

A selective condensation of articles—presenting new developments and ideas in materials and their processing—from foreign journals and domestic publications of specialized circulation.

Edited by H. R. CLAUSER

Aluminum Alloys at Low Temperatures

Low temperature tests down to −300 F n three aluminum alloys are reported by . Wellinger and A. Hofmann in the Aug. 948 issue of *Zeitschrift für Metallkunde* German). The materials tested were pure luminum, an aluminum alloy with 2.8% agnesium, and one with 2% manganese nd 2.3% magnesium. In the static tests, articular emphasis was placed on the de- rmination of properties that would indi- ate clearly the changes caused by the low mperatures. The values obtained included he "effective" tensile strength, cohesive trength, yield strength, fatigue strength, longation, reduction of area and uniform eduction of area. Both notched and un- otched specimens were used for the ten- ile tests.

The fatigue limit increased only slightly with decreasing temperature. The effect of the low temperatures was more pronounced, however, for higher alternating stresses that caused failure in a finite time. In the tensile tests, the lower temperatures caused the greatest change in the values involving more deformation. For example, the low- ering of temperature increased the cohesive strength more than the 0.2% yield strength. Both the deformed and undeformed material showed a higher cohesive strength at the lower temperatures. Although the resistance to deformation was higher at these tempera- tures than at room temperature, the amount of permanent deformation was at times even greater that at room temperature.

The change in properties could be ex- plained by the effect of temperature on the strength properties, on the one hand, and on the ductility properties on the other hand. Although the fatigue strength cannot be compared with the static strength proper- ties, there is an analogy in the effect of low temperatures on the yield strength and fa- tigue strength, since in both cases the nominal stress is determined by very small amounts of slip with the crystallites.

Special Light Alloys for Electrolytic Polishing

Commercial electrolytic polishing has not always proved satisfactory for aluminum alloys. J. Herenguel and R. Segond in the Oct., 1948 issue of *Revue de l'Aluminium* (French), discuss two alloys that are ideal for this purpose and indicate certain proc- essing procedures that must be observed for best results.

Practically, electrolytic polishing is always followed by anodic oxidation, so the mate- rial must be suitable for both; in composi- tion, the material should be as uniform as possible with no second phase out of solu- tion. Two alloys that have been introduced in France for electrolytic polishing contain 3 and 5% magnesium, respectively. The 3% magnesium alloy is the most common, while the 5% alloy is used only where higher strength is necessary.

The solidification should be rapid to ob- tain a fine grain and a uniform distribution of the Al_3Mg_2. Semi-continuous casting is recommended. The mechanical working should be sufficient to assure perfect homo- geneity; press-drawing, then cold working and annealing is most favorable. The final working and annealing should produce a fine grain size and avoid any texture or pre- ferred orientation. The cold working should be above 25% to avoid subsequent grain growth, with an upper limit of 200 to 300% reduction between anneals to avoid preferred orientation.

Heating should be rapid, with the an- nealing temperatures between 615 and 795 F. The lower limit assures a full anneal and the absence of orientation, while the upper limit avoids grain growth. The 5% alloy should never be heated to a tempera- ture lower than 520 F, and should always be cooled rapidly to prevent precipitation.

These two alloys, treated as indicated, are almost perfect for electrolytic polishing and anodic oxidation. Moreover, they do not require high purity aluminum. It should be noted that composition is not the only factor in obtaining the desired results; the processing is equally important.

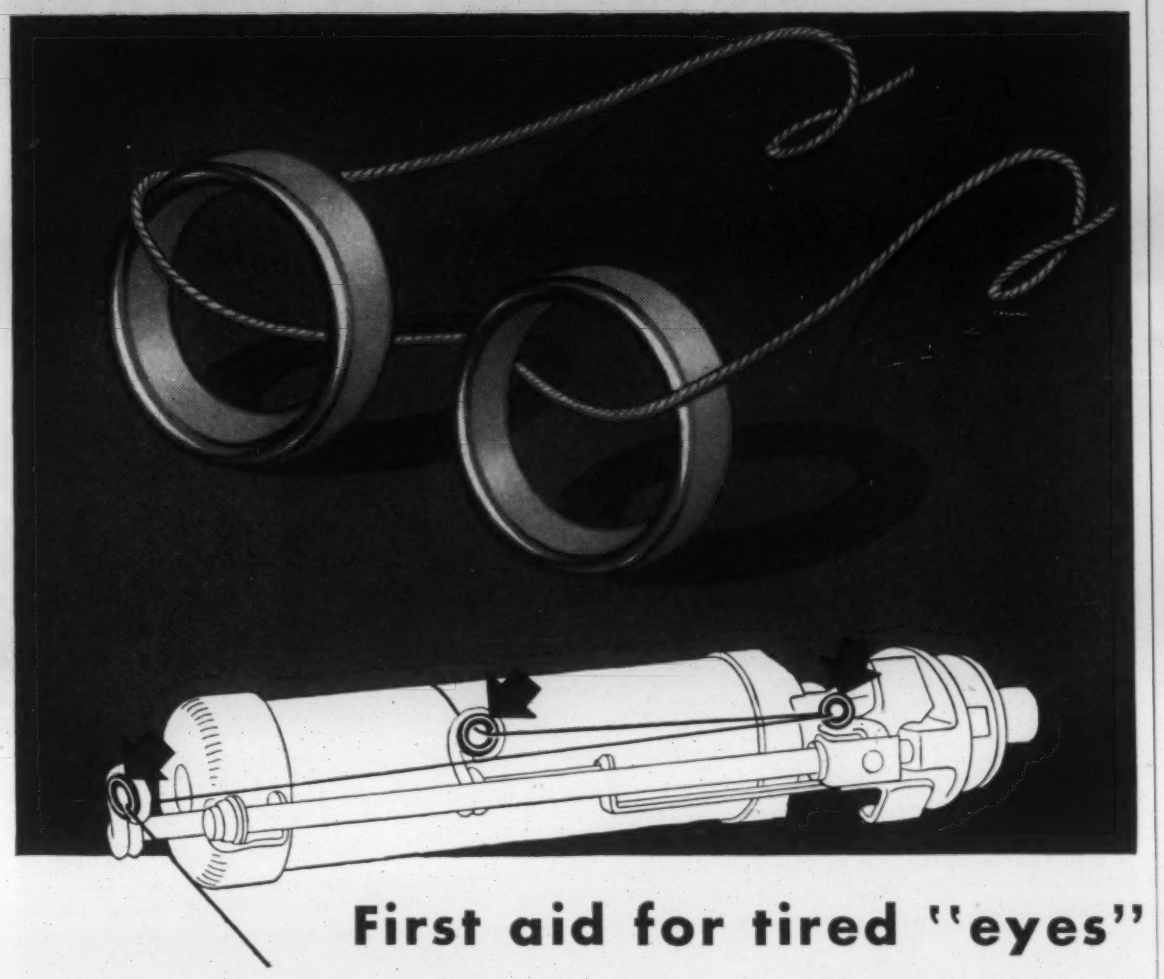
Electrodeposition of Plastics

Although electrodeposition of rubber has been successfully done for about 25 years, very little has been accomplished to extend the method to the field of synthetic resins. Interesting work on the electrodeposition of plastics has been reported by C. G. Fink and M. Feinleib in the *Journal of the Electrochemical Society,* Dec., 1948. Most of their work was accomplished with Saran latex (a vinylidene chloride—acrylonitrile copolymer), Geon (polyvinyl chloride), and styrene-butadiene copolymer.

Good anodic deposits several millimeters thick were built up rapidly. The deposition was characterized by high current yields, comparable with those obtainable with rub- ber latex, and exceptionally high energy yields. By suitable choice of anode material and of heat treatment, deposits may be ob- tained that are either soft, flexible and elas- tic, or tough and stiff, comparable with hard rubber.

Saran electrodeposits, after a short heat treatment, are dark yellow to brown if

WHEREVER THERE'S MOTION there need not be ~~THERE'S~~ WEAR



First aid for tired "eyes"

YOU can't beat Carboloy Cemented Carbide for wear-proofing! Here's an example from the textile industry:

Abrasive raw silk and other threads, constantly rubbing against *steel* thread-eyes, *wore them out rapidly.* Downtime, frequent replacements were costly.

Steel rings were replaced by *Carboloy* thread-eyes, which *show no signs of wear after a whole year of use!* Yes, these Carboloy rings have lasted up to 100 times longer!

Don't pay wages to wear!

Such amazing performances are not unusual with Carboloy. In the automotive, sheet-metal, wire, tubing, and almost *every* industry, the qualities of Carboloy Cemented Carbide have made it indispensable to efficient operation.

For Carboloy Hard Metal is *the hardest metal made by man!* Look at these characteristics:

- **Extreme hardness**
- **High abrasion resistance**
- **Extreme density**
- **High modulus of elasticity**
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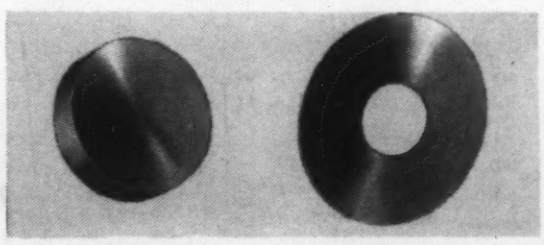
- **High compressive strength**
- **Corrosion resistance**

Would *you* like the life of some of your machine or product parts to jump by as much as 100 times? Carboloy has done it for others, time and again!

For such uses there is a wide range of low cost standard Carboloy parts, hundreds of sizes—many diversified shapes to choose from.



These discs, from Carboloy's stock of wear-proof parts, are used extensively on tools, fixtures, and machine parts, both on new products and on emergency repair jobs.

Any place in your operations or product where wear occurs, Carboloy can probably bring you savings. Look for such places—or better yet, *call in a Carboloy engineer.* Let *him* seek out the spots where Carboloy Hard Metal can cut, or even eliminate, replacement costs and other expenses that wear is costing you.

Contact Carboloy. Take unnecessary wear costs *off your payroll!*

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DIGEST

deposited on a diaphragm or on a zinc electrode. They are comparatively tough, but still quite flexible. Geon electrodeposits are translucent to transparent, colorless to slightly yellow. They are softer, more elastic, and less tough than Saran films. The styrene-butadiene copolymer deposits turn slightly yellow with aging. With time, the film becomes oxidized and loses flexibility and elasticity.

The applications of electrodeposited synthetic resins are in general the same as those of rubber deposition. These include electroforming of sheets or articles directly, electric insulation, protection of metals against corrosion, and abrasion. The equipment required is simple, and power consumption for synthetic resins is even lower than for rubber plating.

What Causes Graphitization?

A unique and rather startling theory is propounded by G. Dague and A. Tabary in *Revue de Métallurgie* (French), May and June, 1948. They begin by a discussion of the extensive American work on graphitization, which was started by the Springdale failure of a welded steel steam pipe due to graphitization adjacent to the weld. It is then suggested that graphitization may be the cause of the other phenomena, namely: flakes, aging after cold working and temper brittleness.

They state that graphitization and temper brittleness both develop in steels that have passed through the martensitic stage. Also, abnormal and fine grained steels are particularly susceptible to all four phenomena. Moreover, these four phenomena are a function of heating below the Acl temperature and of the holding time at a critical temperature, generally in the range between 1110 and 390 F. Therefore, they conclude that graphitization, aging, flaking and temper brittleness are merely different aspects of the same basic change, that is, the shift from the metastable iron-cementite system to the stable iron-graphite system.

No data are given to support the new theory. Some of the difficulties inherent in this theory are clear from the paper itself although no indication is given of how they can be explained. To take one example, chromium is listed as promoting the susceptibility to temper brittleness, but as greatly decreasing the graphitization of low carbon steels. If the basic cause of temper brittleness is graphitization, it would seem that alloying elements would have to have the same effect on both phenomena.

DIGEST

Review on the Fatigue of Metals

With the constantly increasing number of papers on special phases of fatigue, engineers will welcome the concise review of recent work in this field by P. Feltham in the Oct. 1948 issue of *Iron and Steel* (English). Metals, as generally used, are inhomogeneous from the point of view of microstructures and material properties, so that the various crystal domains in a part subject to cycles of stress will not have the same strength and will deform plastically and work harden at different rates. The repeated application of stresses above the fatigue limit is accompanied by a cumulative storage of energy within the specimen in addition to the energy dissipated as heat.

Part of the stored energy is recoverable, being latent strain energy, while the rest is not recoverable and appears to be used in forming the fracture surface of fissures. The fissures develop at weak points in the part, as on the boundaries of soft and hard material and in regions embrittled by cumulative cold work. The growth in numbers and dimensions of such faults finally entails the fracture by fatigue of the part.

The small size of the fatigue faults and their random dispersion make the task of predicting the life of a part a very difficult one. Most applied methods confine themselves merely to the detection of fatigue cracks late in the tests. A method for predicting fatigue which would be scientifically sound and yet applicable under practical engineering conditions has not yet been developed. It is suggested that the present picture of the mechanism of fatigue be used in guiding future research on this problem by way of a statistical approach to the mode of formation and propagation of fissures in polycrystalline metals. Developments along these lines seem likely to lead eventually to shorter methods of fatigue testing and more reliable means of predicting fatigue failures than those now in use.

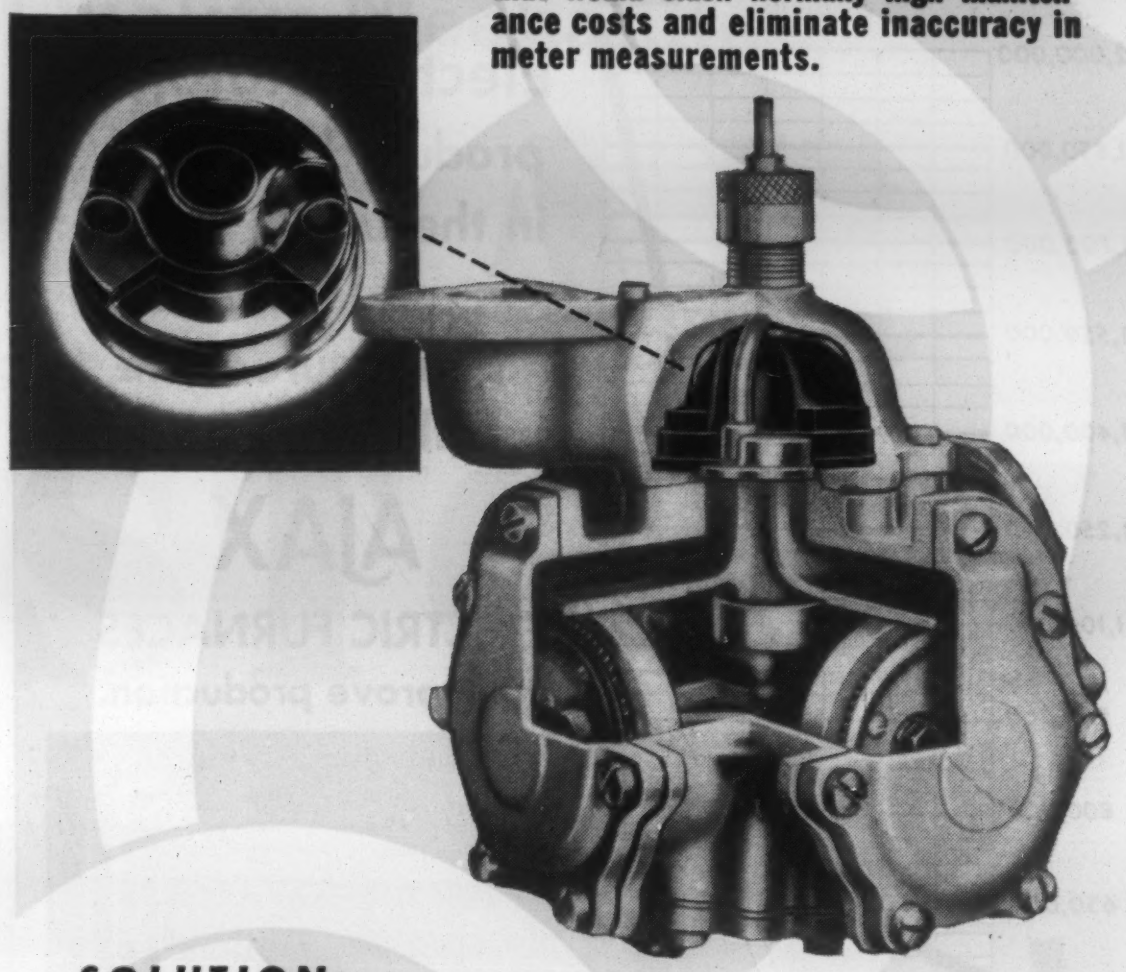
Welding High Strength Aluminum Alloys

New findings on the welding of high-strength aluminum alloys are described in a report released by the *Office of Technical Services, Department of Commerce.* The work was carried out by the Battelle Memorial Institute.

Three approaches to the improvement of welded joints are discussed in the report: (1) the development of improved filler

PROBLEM:

To supply a rotary valve for gasoline meters that would slash normally high maintenance costs and eliminate inaccuracy in meter measurements.



SOLUTION:

Morganite developed and tested a self lubricating rotary valve suitable for gasoline metering. Tests indicated a 90 % reduction in operating troubles due to friction, gumming or sticking.

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SELF-LUBRICATING
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FOR DETAILED INFORMATION consult the Morganite Catalog in Sweets File for Product Designers; for engineering counsel or specific proposals, call in a Morganite sales engineer. Either way, there is no obligation.

Placed in actual service, results were even better than anticipated. Sticking and friction caused by wax and gumming deposits—the cause of inaccurate measurement and constant service failures—were reduced to the vanishing point.
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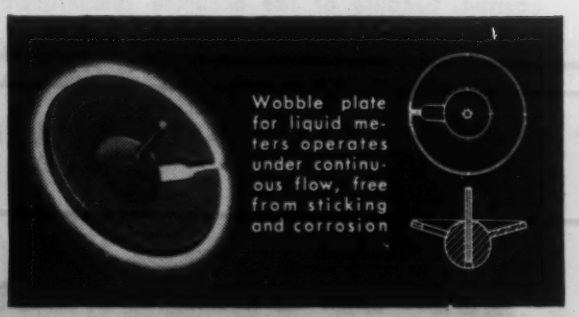

Manufacturers of Morganite Carbon Brushes for all motor and generator applications, and Morganite Carbon Piles.

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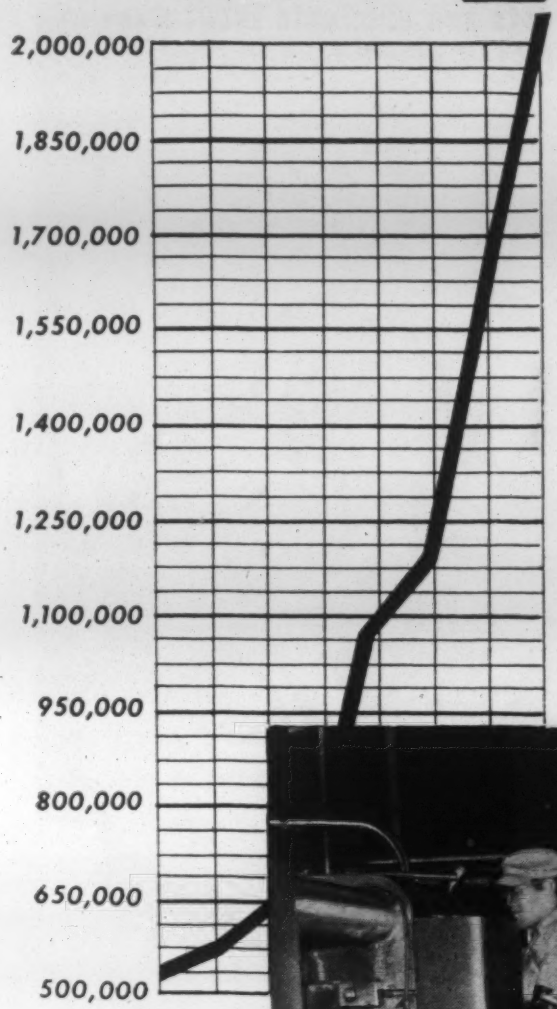
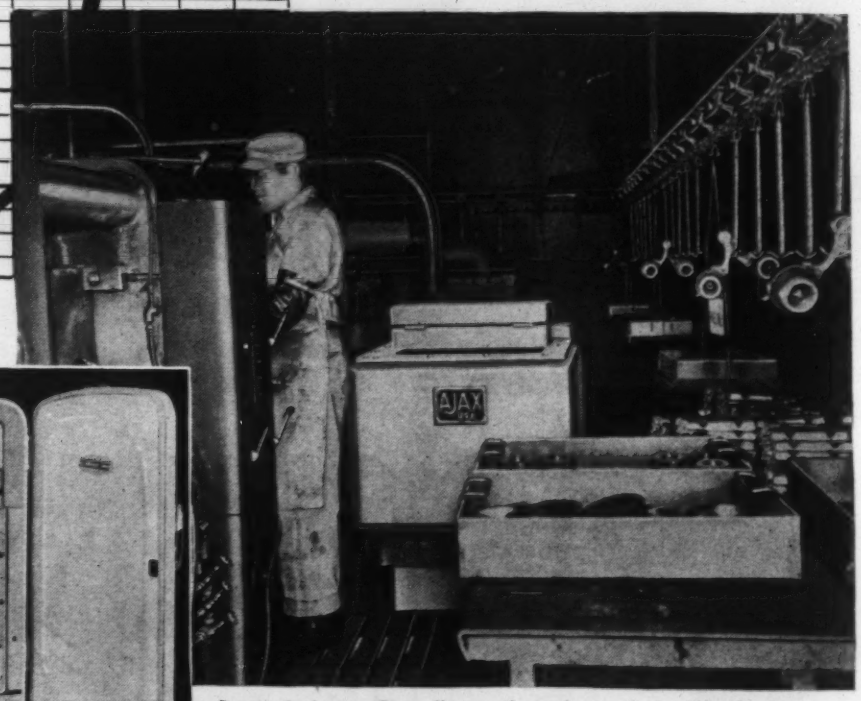


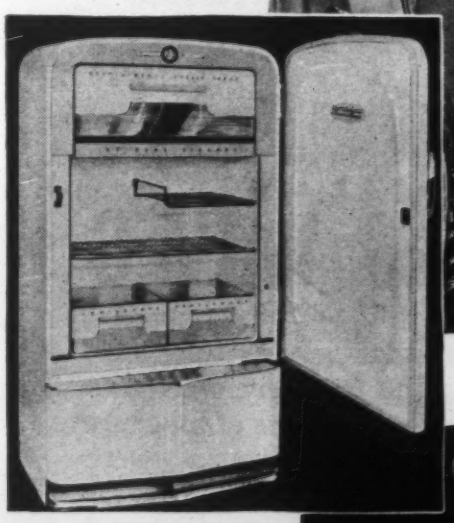
Electric Motors produced monthly in the U.S.A. - - more and more manufacturers are installing

AJAX

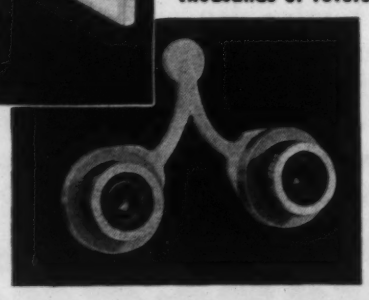
ELECTRIC FURNACES to improve production.



Part of the modern die casting plant of the Westinghouse Electric Corporation in Springfield, Massachusetts, where thousands of rotors are cast every day for refrigerator units.



The new Westinghouse Refrigerator Model MF-7.



Cast two at a time, these aluminum motor rotors are better because of accurate temperature control and freedom from contamination made possible by Ajax Induction Furnaces.

Included in the millions of motors manufactured nationally, per month, are the hundreds of thousands of fractional horse-power motors that fill the ranks of faithful, alert and silent servants for the American home. Such large output requires ingenious production methods. A great improvement has been achieved by casting the rotors from high purity aluminum. Prominent manufacturers have recognized the advantage of using Ajax-Tama-Wyatt induction furnaces for melting the aluminum prior to casting, because of the accurate temperature control and freedom from contamination with iron or silicon.

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DIGEST

metals; (2) the effects of various heat treatments; and (3) the use of unorthodox joining methods, including cold pressure welding. While work on the two first approaches remains far from complete, promising leads appear to have been uncovered. Unorthodox welding techniques, on the other hand, do not yet seem to offer definite hope for improving the quality of welded joints.

Determinations were made of the strength properties of joints in thick high-strength aluminum alloy plates, welded by conventional processes with currently available filler materials. Conventional welded joints were found to have only from 5 to 30% of the ductility of the parent plates, emphasizing the need for filler-rod alloys that would deposit more ductile weld metal. A few tests completed with "Alcoa 716" filler rod showed consistently superior results to those obtained with 43S filler rods, or alloys of identical composition to the parent metal.

Tensile efficiencies of welded joints were found to be markedly improved by full heat-treating. No work as yet has been done to determine possible advantages of mechanically working welds to improve joint efficiencies.

Priming Paints for Light Alloys

The protection afforded to aluminum and magnesium alloys by various paint primers is being investigated in rural, industrial and marine atmospheres. Although commercial primers are complex mixtures, tests described by J. G. Rigg and E. W. Skerrey in the Oct., 1948 issue of the *Journal of the Institute of Metals* (English), are based on single pigments to simplify the comparison. The four pigments are: zinc chromate, zinc tetroxychromate, iron oxide and red lead.

The first is used extensively in painting light alloys; the second is often considered in the U.S.A. as an alternative material. The last two pigments are commonly used for priming ferrous metals. The specimens were exposed untreated; with pre-treatment as for painting; with one coat of primer only; and with two coats of primer and one of top coat.

Preliminary results show conclusively that red lead primers are unsuitable for light metals because the red lead accelerates the corrosion of these metals. The more anodic magnesium alloys show this effect more markedly than the other metals and suffer corrosion from this cause even in the rural atmosphere. The effect of the red lead becomes more marked as the corrosion condi-

tions become more severe and as the purity of the base metal is lowered.

No acceleration of corrosion has been observed with any of the other paint systems. In fact, iron oxide has considerable merit as a priming pigment on light metals and is providing useful protection even in the more severe saline atmospheres. The chromates appear to be the most successful primers for general use on all the light metals included in these tests. There is some indication that zinc chromates are superior to iron oxide on light alloys, but more prolonged exposure will be required to confirm this.

Melting and Casting of Precious Metals and Their Alloys

Although the general principles of casting precious metals are the same as those for other nonferrous metals, there are certain important differences: high prices, high melting points and relatively small quantities. As set forth by E. Rhodes in *Fonderie* (French), Aug., 1948, the characteristics of these metals of interest are their high melting points, high densities, great resistance to oxidation, and erratic tendencies to dissolve gas.

The purity of the metal is particularly significant, not only because the purchaser does not want to pay a high price for impurities but also because recent work has shown the deleterious effect that even small amounts of impurities may have on the finished product. For example, 0.001% of lead or 0.0005% of bismuth will make the 90% platinum—10% rhodium alloy unworkable.

With one exception, there has been practically no change for years in the melting of gold and silver. This exception is the vacuum melting and casting of silver and its alloys. If it contains even small amounts of dissolved oxygen, silver—like copper—becomes very brittle when heated in a reducing atmosphere. Vacuum-melted silver is not susceptible to this type of embrittlement.

The older method of melting platinum and palladium with an oxy-hydrogen or oxy-gas torch and a calcined or compressed lime "furnace" is still used because of its simplicity. Larger plants, however, prefer high frequency induction furnaces because of their cleanliness, low melting losses, possibility of controlling the atmosphere, stability of composition when melting alloys, and excellent mixing due to eddy currents.

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ment casting is given as well as a general review of the properties and applications of precious metals and their alloys.

Tin and Tin-Lead Alloys for Low Temperature Service

Tin-lead solders are being used extensively in refrigeration and gas liquefaction equipment, so a knowledge of their low temperature tensile properties is important. A paper in *Metals Technology,* Sept. 1948, describes the results of an investigation on this subject conducted by H. S. Kalish and F. J. Dunkerley. Their survey included tin and a series of pure tin alloys containing from 0.01 to 50% lead tested at temperatures from –320 to +68 F.

Here are a few of their findings: (1) Lead in tin up to about 1.6% is responsible for loss of ductility and a gain in ductility above this composition between –320 and +68 F. (2) Additions of lead up to 1.6% increase the ultimate tensile strength slightly in the same temperature range. (3) Tin and tin-lead alloys increase in strength as temperature decreases prior to embrittlement. (4) A 50-50 tin-lead commercial solder was brittle below –238 F, its ultimate tensile strength increased to 18,500 psi.

Solders of higher lead content will become brittle only at successively lower temperatures until at about 70 to 80% lead, the alloys should remain ductile down to temperatures near absolute zero.

Die Casting Dies by Powder Metallurgy

A development in die construction technique that may prove of importance is a recently introduced process for the reproduction of cavity inserts by powder metallurgy. Since die sinking is the most skilled and, usually, the most costly operation in making die casting dies, the commercial exploitation of this new method is likely to make die castings practicable in many of the marginal applications where the capital cost of tools has hitherto precluded a change from less efficient processes. The advantages and disadvantages of sintered die inserts are discussed by H. K. Barton in *Metal Industry* (English), Oct. 29, 1948.

By forming the cavity to finished shape in a sintered insert, a double advantage is gained: the material used may, if neces-

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DIGEST

sary, be one that is unmachinable by ordinary die sinking methods, while it also allows easy reproduction of shapes that would be difficult to form even in a steel of good machinability. A disadvantage is the limitation on the size of the insert that can be produced by powder metallurgy. U.S. Patent 2,413,512 covers a method of producing sintered die cavities with the use of an existing die casting as a master form. The casting is left in place when the pressing is completed and is melted out during sintering. It is also possible to use master patterns of low melting point alloys.

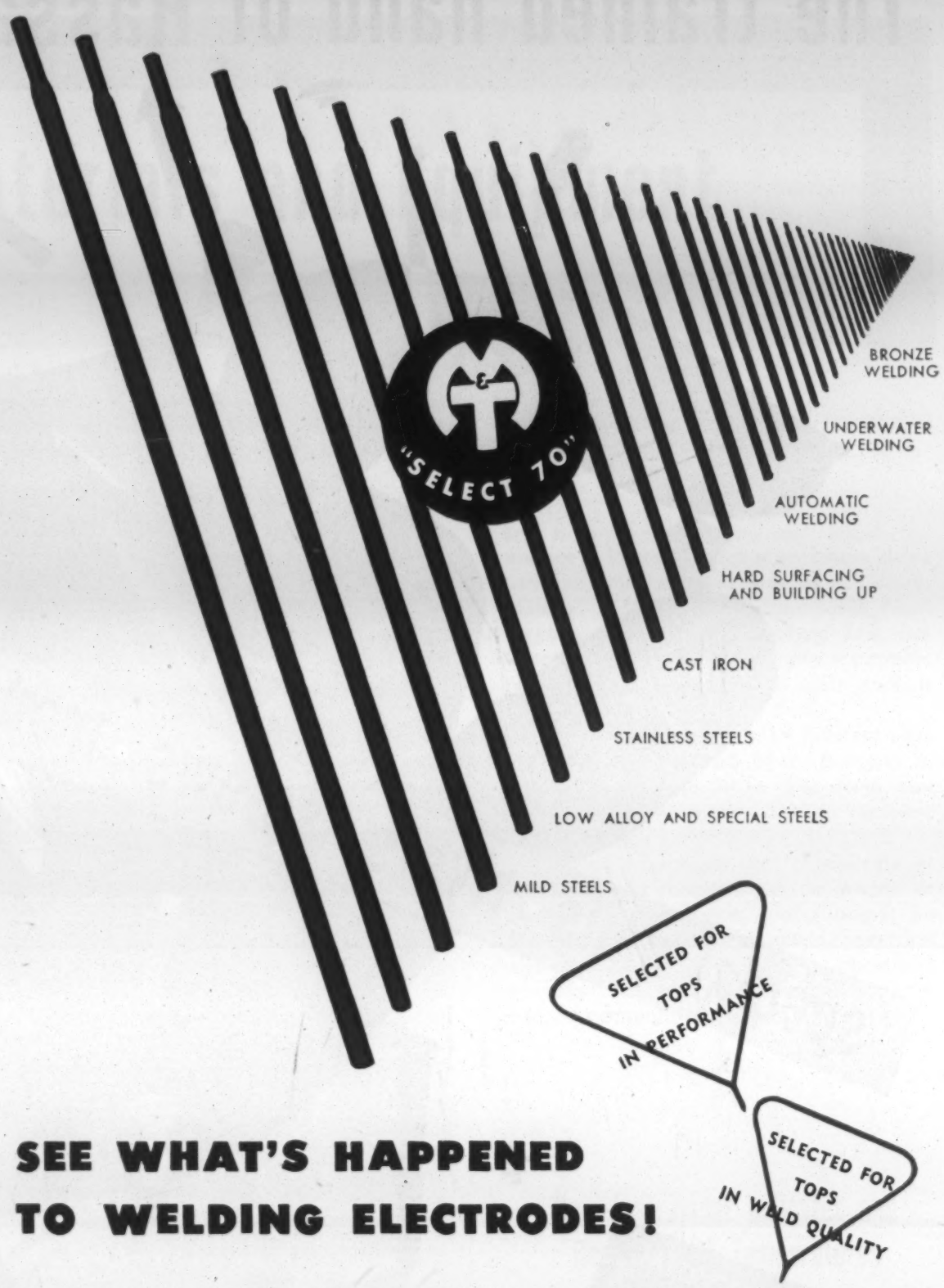
Although further experimental work is needed before the process can be used commercially, reproduction of cavity inserts by powder metallurgy has many attractive possibilities. Like other short cut methods of die forming developed during recent years, such as precision casting of cavity inserts and their formation by the mounting of an electrodeposited shell in a beryllium-copper matrix, application is likely to be directed initially to tools for the molding of plastics or rubber before a stage is reached where the more severe conditions of die casting can be successfully and consistently met.

Nylon as a Bearing Material

Nylon is finding a steadily increasing number of industrial applications. R. B. Akin, in a paper delivered before the *American Society of Mechanical Engineers*, Dec., 1948, described the use of the nylon plastic, known as type FM-10001, for bearings. Of the dozen types of nylon now in commercial production as plastic molding powders, this one is the most rigid, has the highest softening temperature, and is the least expensive. It is handled by the injection molding process. Bearings can be molded for machining where the number of pieces is not great enough to warrant molds of special shapes.

Nylon bearings require no lubricant for a light load at high speed or for a moderate load at low speed. Their load-carrying ability and temperature range are approximately those of Babbitt with better abrasion resistance. From tests conducted on nylon bearings, their limiting loads appear to be: with oil as a lubricant, 1550 psi.; with water, 1050 psi.; with no lubricant, 550 psi.

Because of its resilience, nylon deforms elastically at points of stress concentration, thus distributing the load over a large area. Motor oils do not affect nylon at temperatures as high as 325 F, nor are oils adversely affected by nylon.



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Yes, now there are 70 types of electrodes in the M & T line — each one selected from a number of designs to give top performance on a particular class of work — each one picked to help you do the best possible job, more speedily, at lower cost.

You need look no further than M & T's "SELECT 70" for easy selection of the right electrode for any application. Write today for your brief but comprehensive catalog.

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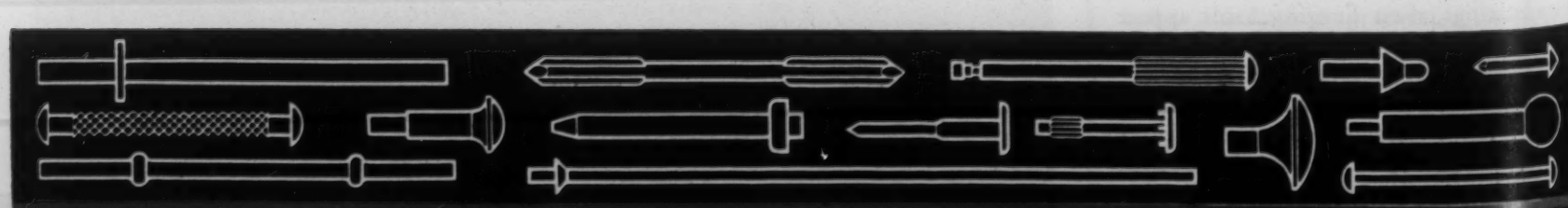


JOHN HASSALL, INC. • 162 CLAY STREET • BROOKLYN 22, N. Y.

New Materials and Equipment

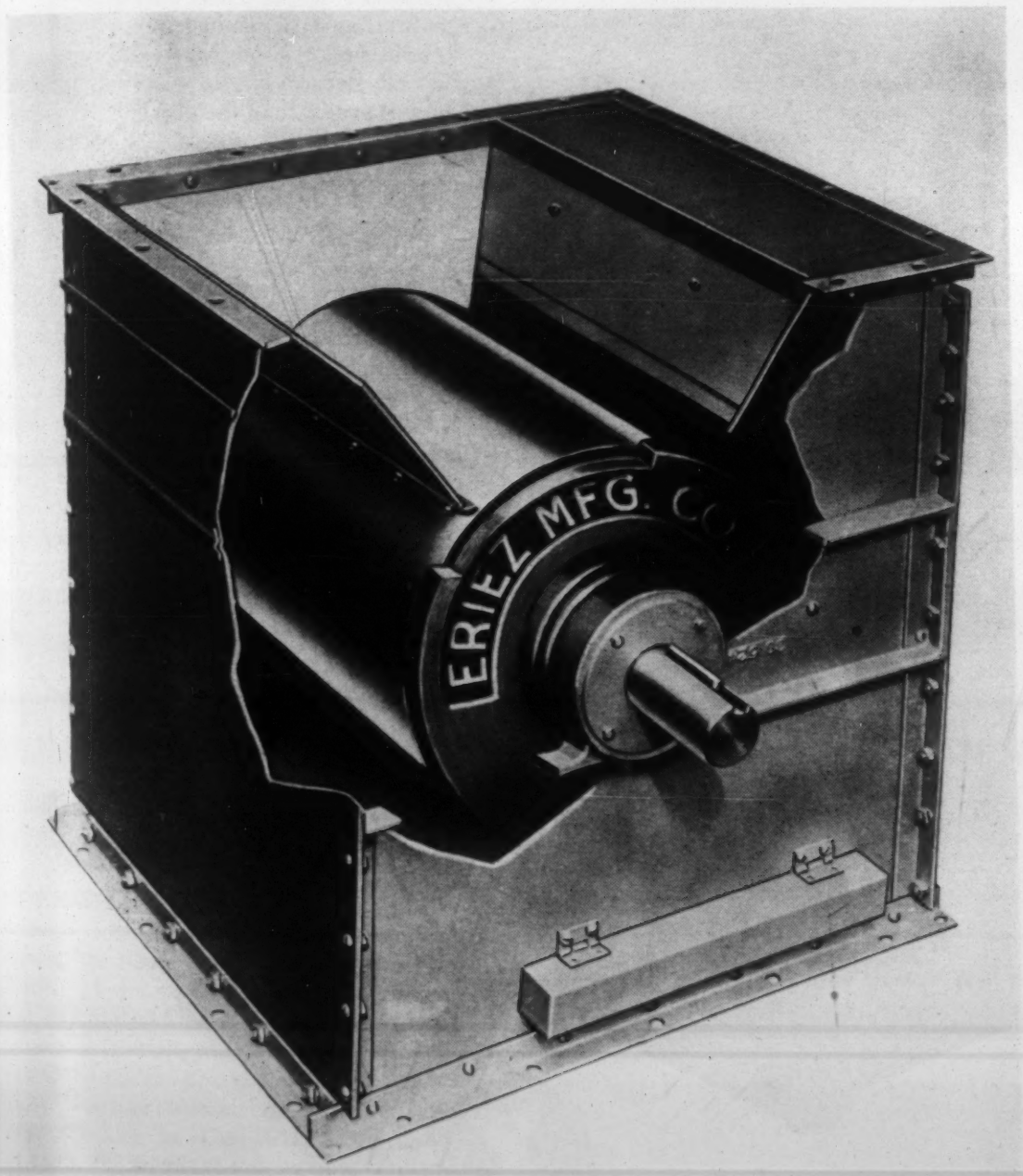
Magnetic Separator Is Nonelectric

A completely self-energized magnetic drum requiring no electric current to produce a magnetic field has been announced by the *Eriez Manufacturing Co.*, 569 E. 12th St., Erie, Pa. Powered by Alnico magnets, the unit is adaptable for the automatic removal of tramp iron and fine ferrous contamination where materials are conveyed in spouts, chutes and other similar conveying systems not employing belts. Such materials as grain, tobacco, plastics, ceramic sands, ball clays, powders, crumb rubber, chemicals, etc. are readily purified of iron contamination. It is used equally as well for the separation of ferrous from nonferrous metals.

The drum separators consist of a revolving cylindrical shell within which a stationary high-powered permanent nonelectric magnet is located. The magnet covers about half the cross sectional area of the drum. Material is fed onto the drum shell. Nonmagnetic material is discharged first and separately, while the magnetically susceptible portion is held against the shell until it passes out of the magnetic field.

The unit is available in 18 different sizes including 12-, 18- and 24-in. dia. and in drum widths up to 50 in. The drum may be ordered as a separate unit or complete with housing.

Claimed advantages are: elimination of operating and maintenance, no wiring or electric current needed; cool running; no loss of magnetism through heating; electrical system failures have no affect on operation; not affected by inadequate ventilation, moisture or variations in field strength.



This self-energized magnetic drum is useful for separating ferrous from nonferrous and metallic materials.

New Instrument Indicates and Records 160 Temperatures

A new instrument by *Leeds & Northrup Co.*, 4934 Stenton Ave., Philadelphia 44, automatically logs as many as 160 separate thermocouple temperatures in succession at a rate of 4 sec. per point. Because each point is checked at such frequent intervals, high or low temperatures which may develop can be spotted before serious trouble results.

In case of trouble, the operator can cut thermocouples out of the measuring sequence in banks of 20 at a time, until the instrument is concentrated on the particular group of temperatures in which he is interested at the moment. Or, he can set the instrument to record any single thermocouple, or to record all points continuously.

In usual operation, the instrument simply indicates while numbered lights identify each couple. Should any temperature reach a preset limit, the instrument automatically starts its recording chart drive, begins to record all points as a series of numbered dots, and operates an alarm.

New Materials and Equipment

(CONTINUED)

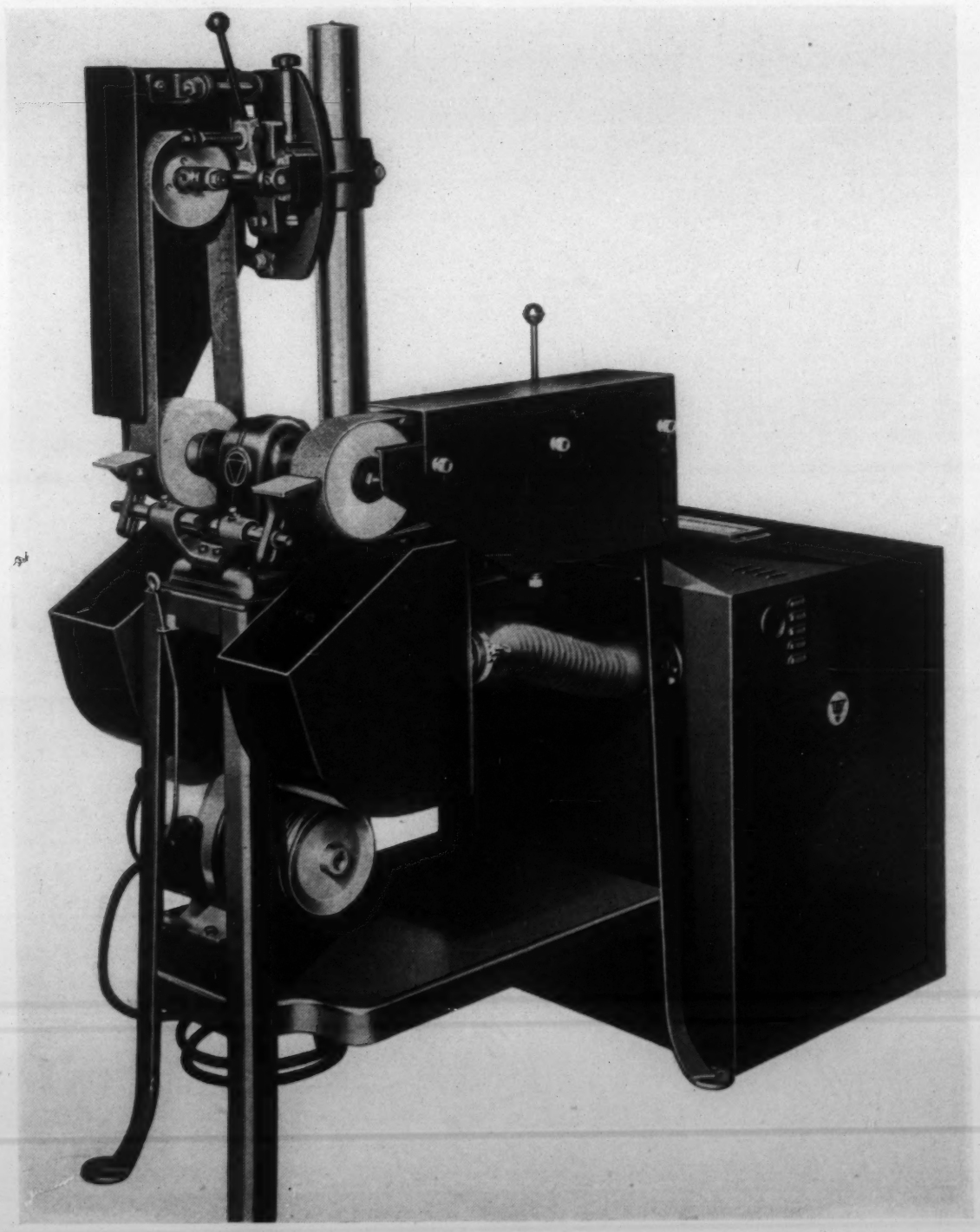
Belt Grinder Polishes, Deburrs and Grinds Metal Parts

A new H-type grinding, polishing and deburring machine is being manufactured by the *Delta Manufacturing Div., Rockwell Manufacturing Co.,* 600 E. Vienna Ave., Milwaukee 1, Wis. This new machine, using coated abrasive belts, is a portable unit, coming in four different models.

One of the features of the machine is its adaptability for the use of two different quality grit belts at the same time. In addition, the machine easily can be converted into a buffing machine. All four basic models consist of the arbor head, an idler unit, a straight-faced contact roll, and abrasive belts.

Aluminum oxide belts in four different grits are available for general purpose on steel, brass, forgings, die castings, and some plastic materials. Silicon carbide belts are recommended for hard materials of low tensile strength.

Virtually any desired finish may be had with this belt grinding, polishing and deburring machine. Some of the jobs it is capable of are: cleaning out slots, removing flash in corners, removing fins, removing drilling burrs, removing nibs, removing flash between bosses, removing saw burrs, removing milling burrs, removing parting lines and deep scratches, removing tapping burrs and grinding lines, cleaning out corners, chamfering corners, breaking corners, rounding off slots, and grinding off excess stock.



This grinder can be easily converted into a buffing machine.

New Welding Rods and Electrodes

A new internally fluxed gas welding rod for welding deoxidized copper is offered by *Arcos Corp.,* 1500 S. 50th St., Philadelphia. The self-fluxing property of the rod, called Silbrax, prevents repeated rod oxidation and hence faulty weld metal. Because the rod is fluxed internally, the heat is applied first to the metal and then transmitted to the flux. It therefore keeps a proper balance at all times between melting metal and flux. This rod is also used as a filler rod for carbon and inert arc welding.

Arcos Corp. has also announced Monend 806 electrodes for welds on Monel, Monel clad, and steel. The electrode eliminates the necessity of depositing a buffer layer of nickel. It has a spray type arc which is said to have excellent stability that facilitates all-position welding. Free-bend specimens exhibit high elongation values, normally 50% or higher; typical weld metal yield strength is 42,500 psi. and tensile strength 75,500 psi.

The *Champion Rivet Co., Welding Div.,* Cleveland, has announced its new HY-LO electrode A.W.S. E7015 for the welding of high sulfur, high carbon, low alloy high strength and hardenable steels. The electrode can also be used to weld parts that are to be galvanized or porcelain enameled, steel of doubtful analysis, manganese or spring steel to mild steel, locomotive frames and flexible staybolt sleeves, etc. In addition, this electrode is available in the higher tensile ranges of A.W.S. E8015, E9015 and E10015.

● A deep-drawn rolled-thread insert for use in molded plastic die casting and rubber products has been announced by *Clover Industries, Inc.,* 539 Ellicott St., Buffalo, N. Y. Made of light gage steel, the inserts are said to cost approximately one-half as much as brass screw-machine parts of the same size. The inserts show good anchorage characteristics. Because of their very thin wall sections, they can be located closer to the edges or corners without risk of cracking the molded part.

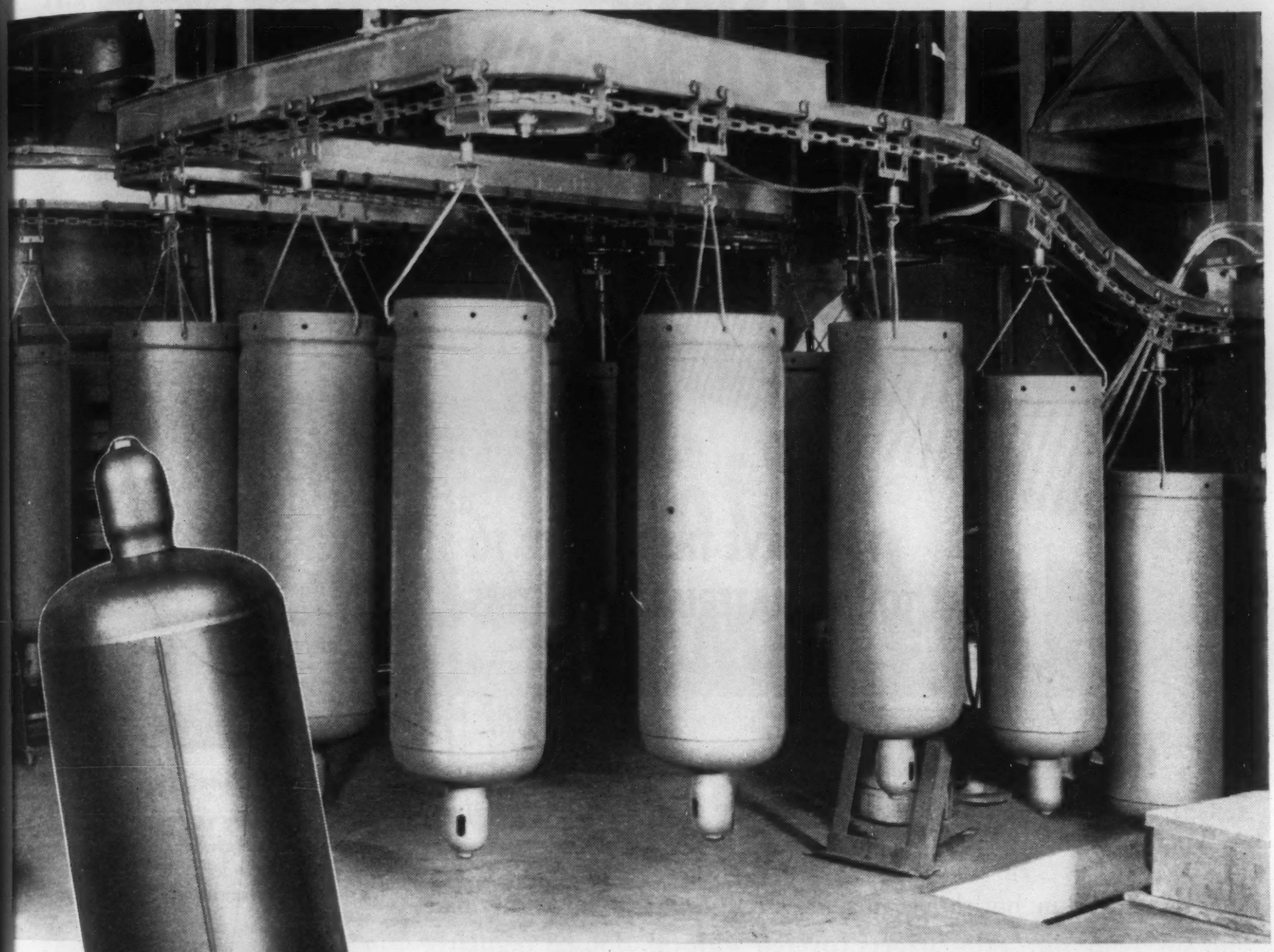
Densitometer Accurately Determines Color of Painted Surfaces

A direct reading color densitometer for the precise determination of the color of solid substances such as enamels and painted surfaces has been announced by *Ansco,* Binghamton, N. Y. The densitometer is a precision electronic photometer of the direct reading type. It permits measurement of color densities in narrow spectral ranges (blue, green and red) as well as visual densities over an unusually wide range.

The instrument is said to provide a high degree of sensitivity and stability. It gives automatic dial-indicated readings and thus prevents inaccuracies caused by fatigue, lack of training and careless observation.

N-A-X HIGH-TENSILE STEEL in L.P.G. Cylinders

means light weight with added safety and durability



Photographs of the Lee cylinder, courtesy of the Steel Cooperage Company, Detroit.

Because of the greater strength and excellent fabricating, welding and copper brazing properties of this low-alloy, abrasion- and corrosion-resisting steel, cylinders made with it (to conform to I.C.C. safety requirements) are 35% lighter in weight than when made with conventional carbon steel.

This weight reduction (with longer life) means greatly reduced shipping and handling costs . . . and over-all savings to consumers.

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Specify—
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If you use an Ace *hard rubber* comb, you have a materials testing lab right in your pocket, for a good comb has to meet specs that are *tough!*

It's light and thin, but shows amazing strength in taming knotty hair and surviving 6-ft. falls. It gets covered with oil, doused regularly in hot water and sterilizing chemicals, yet a genuine hard rubber comb lasts for years.

It's a good example of fabricating, too. It starts as a molding. The teeth are machine-cut. Finally, a series of grinding and polishing operations give it that smooth, satiny feel.

Best for nearly 100 years, there still is no other material as good for combs. It shows you why Ace hard rubber is preferred in thousands of parts for machines, appliances, automobiles, furniture, etc. Other important Ace plastics also available.

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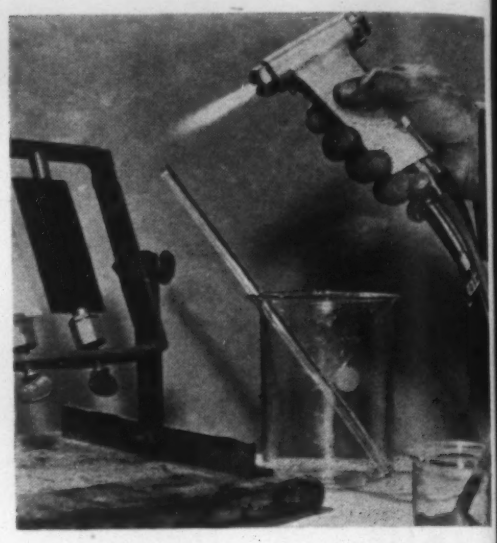
New Materials and Equipment

Flame Spray Pistol Handy for Small Jobs

A small size flame spray pistol has been developed by the *Schori Process Div., Ferro-Co Corp.*, 8-11 Forty-Third Rd., Long Island City 1, N. Y., for use where grams or ounces of powder may be sprayed instead of pounds.



The laboratory size spray gun in action.

This laboratory size pistol will spray any metal or plastic powder or mixtures of metal and plastic powders. It also can be used for heating, brazing and soldering.

Lithium Atmosphere Furnace Prevents Scaling

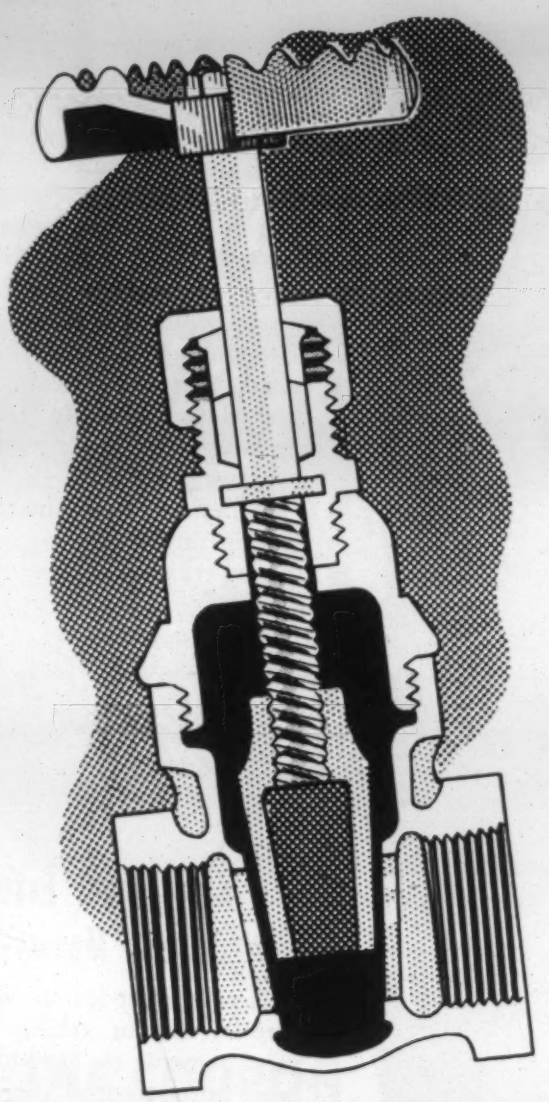
A direct fired lithium atmosphere forge furnace in which forgings are heated free of scale has been developed by the *Lithium Co.*, 11 Sylvan Ave., Newark, N. J.

It produces an atmosphere condition in a direct fired furnace which is said prevents the usual scaling losses occurring in forge furnaces. Thus, steel can be heated for forging without the necessity of subsequent sandblasting, pickling, tumbling and other methods of removing scale.

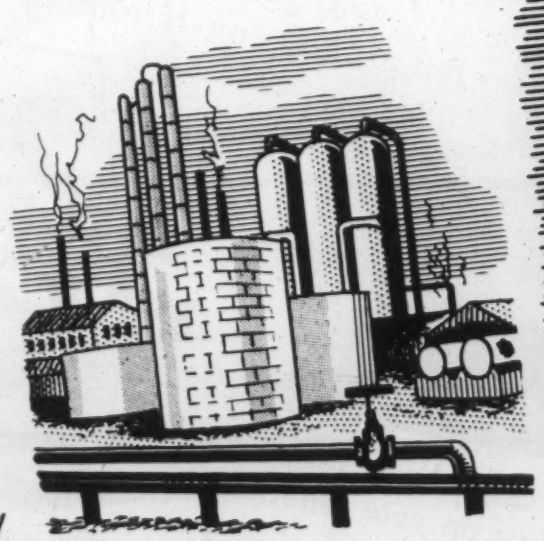
A suitable carrier gas from a gas generator is passed through the vaporizer tube where it mixes with vaporized lithium coming from the lithium vaporizing chamber, thus providing the necessary protective atmosphere at the work. In addition, the slight coating of lithium which is imparted to the metal surface is said to insure against scaling while the metal is being removed from the furnace to the press, upsetter or

(Continued on page 104)

BRONZE VALVES ARE SELECTED TO CONTROL . . .



Many Flow Problems of Modern Industry



Bronze and nickel silver valves meet the requirements of many industrial flow control problems. First, because of the satisfactory engineering properties: pressure tightness, strength, ductility, and resistance to corrosion and erosion. Second, because of low foundry costs and excellent machinability. And third, because of their dependable service and long life.

Cast bronze meets the requirements of industry and consumer.

Specify—LAVIN NON-FERROUS INGOT—*Quality*

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LOW TEMPERATURE
FLUX

Best for brush application and lowest melting solders. It's smooth as cold cream — doesn't lump or harden and removes readily in cold water. You'll find No. 1100 easy and convenient to use on both ferrous and non-ferrous metals.

1200
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FLUX

Universal because equally good for dipping and brushing, lower or higher temperatures. A superior all-purpose flux for production brazing of ferrous and non-ferrous metals. Doesn't rise or glare.

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PRECIOUS METALS SINCE 1875

231 NEW JERSEY R. R. AVENUE
NEWARK 5, N. J.

New Materials and Equipment

hammer during hot working, and during cooling.

The furnace is constructed of a heavy steel sheet provided with a thick wall of refractory and insulating material. The unit is direct fired, utilizing oil or gas, or oil and gas in combination.

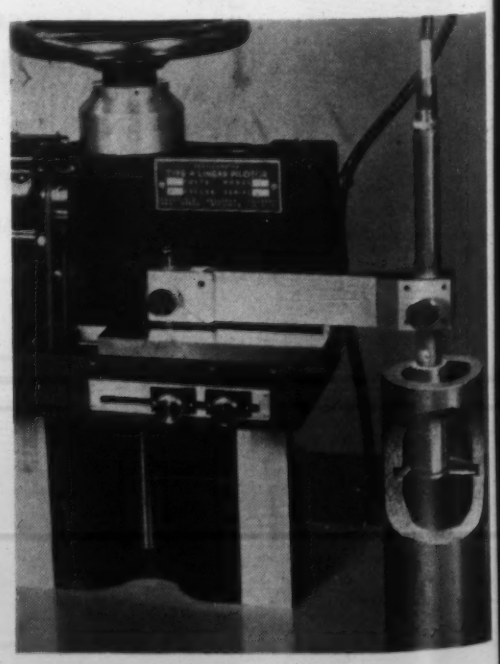
The furnaces are available in standard single and double slot and continuous types. The single slot types run from 12-in. slot width and 8-in. hearth depth, to 64-in. slot width and 24-in. hearth depth. These furnaces are also built in double slot types for double capacity.

If desired, the lithium atmosphere generating unit and vaporizer can be adapted to conventional forge furnaces or any other direct fired batch or continuous heating furnaces operating at 1400 to 2300 F to give the desired protective atmosphere.

New Tracer Extends Use of Roughness Measuring Instrument

A new tracer for use with all Profilometer amplimeters in taking surface roughness measurements on hard-to-reach surfaces has been introduced by the *Physicists Research Co.*, 321 Main St., Ann Arbor, Mich. Known as the Type GB Tracer, this unit provides for measuring on internal grooves and slots, tracing axially in small holes, tracing both transversely and longitudinally in narrow slots and grooves and on gear teeth, and tracing on internal and external tapered surfaces.

In order to enter small holes and slots, the tracing point is located at the end of a



Cut-away view showing tracer being used on an inside surface.

FIRTHITE SINTERED CARBIDE,

used in your shop tooling brings

—more rapid removal of material
—increased production runs
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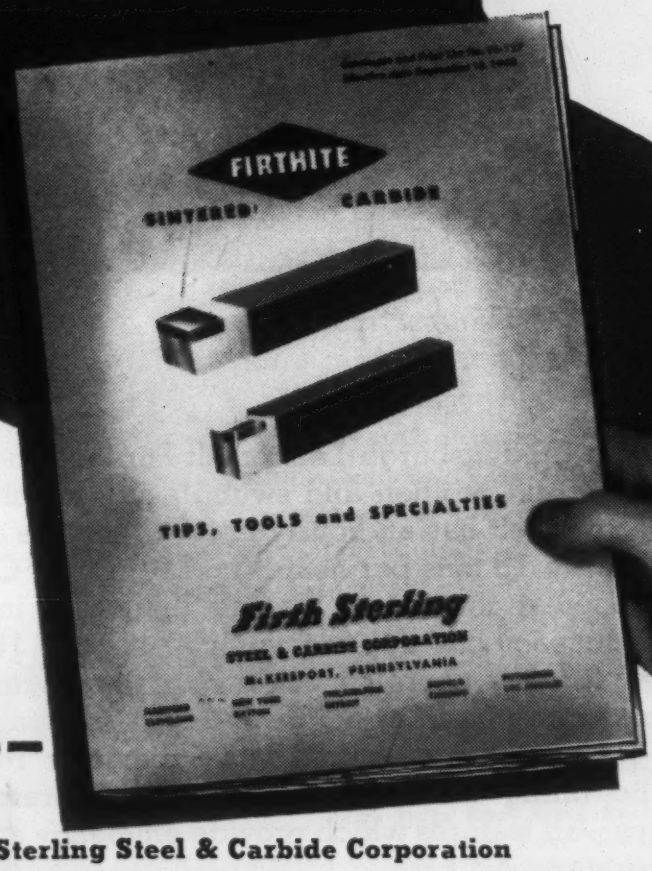
—cutting of so-called unmachinable materials
—holding of closer tolerances
—longer tool and die life

. . . all of which adds up to higher production at lower costs



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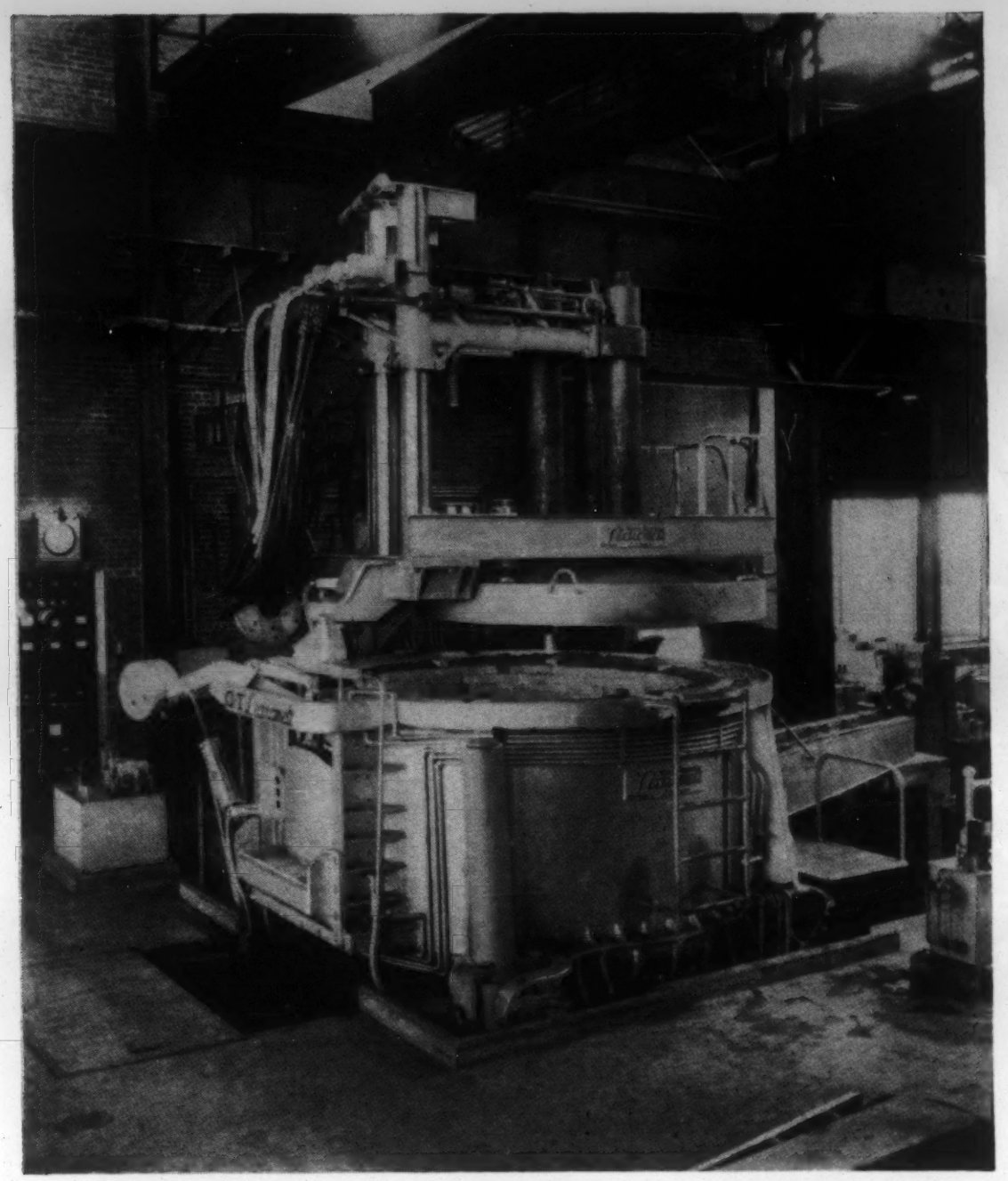


A size OT Pittsburgh Lectromelt Furnace shown with the roof in raised position and swung aside for charging. This size Lectromelt has an hourly rating of six tons and normally pours 12 to 15 tons per heat. The Lectromelt OT is particularly popular for use in making billet size ingots and its output capacity is approximately that of a 100 ton open hearth furnace operated continuously on batch cold melt pig and scrap basic or acid working. Note particularly the four point roof suspension, large diameter roof ring, hydraulic tilting mechanism and power-operated electrode clamps—all features which provide efficiency and durability in operation.

For complete information on Lectromelt furnaces in sizes ranging from 100 tons to 250 pounds, write today to

PITTSBURGH LECTROMELT FURNACE CORP.

PITTSBURGH 30, PA.

MOORE RAPID Lectromelt FURNACES

are manufactured in: CANADA, Lectromelt Furnaces of Canada Ltd., Toronto 2; ENGLAND, SWEDEN, AUSTRALIA, Birlec, Ltd., Birmingham, England; FRANCE, Stein et Roubaix, Paris; BELGIUM, S. A. Belge, Stein et Roubaix, Bressoux-Liege; SPAIN, General Electrica Espanola, Bilbao; ITALY, Forni Stein, Genoa

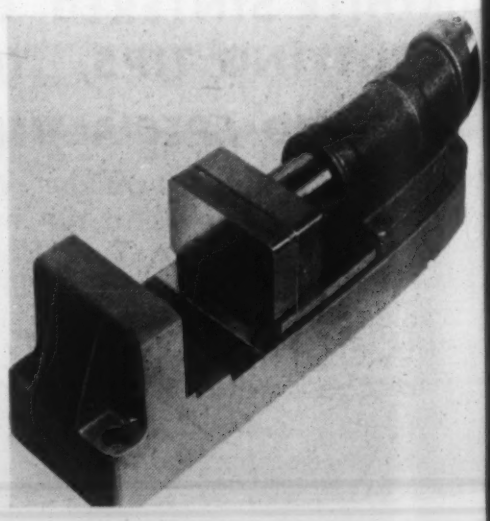
New Materials and Equipment

narrow beam which projects horizontally from the bottom of the tracer, and no skids are used. Because of this construction, the tracer must be operated mechanically by a Pilotor.

This tracer can be used with the beam at any desired angle to the direction of trace. Thus, with the beam at right angles to the path of travel, lengthwise tracing is permitted in slots and on shoulders. It has an internal range of 5/64 in. to flat. It measures in 5/64-in. holes or 1/16-in. slots to a depth of ¼ in., in 7/64-in. holes or 3/32-in. slots to ¾-in. depth, and on gear teeth as small as 18 pitch. The tracer will go into vertical holes of 1¾-in. minimum dia. to a depth of 5½ in., and when used with a Type A Linear Pilotor, has a vertical adjustment of 0 in. to 5⅞ in. above the base plate.

Hydraulic Punching Units for Many Production Jobs

A new line of hydraulic punching units with cylinders interchangeable on different bases has been announced by the *Progressive Welder Co.*, 3050 E. Outer Dr., Detroit 34. These units may be used for many production jobs involving punching, shearing, notching, trimming or forming. They are available in eight different types of base mountings, closed end, open end, floating type, rocker type, front or rear end



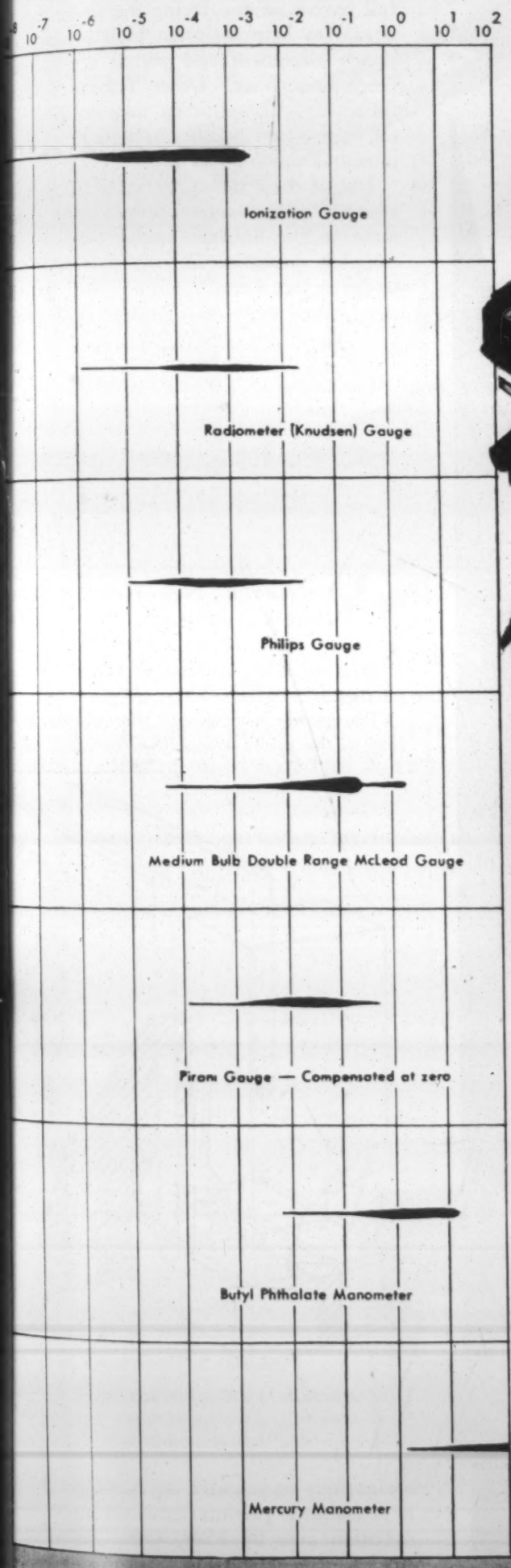
A typical punching unit. Several types of bases are interchangeable with the one shown using the same cylinder.

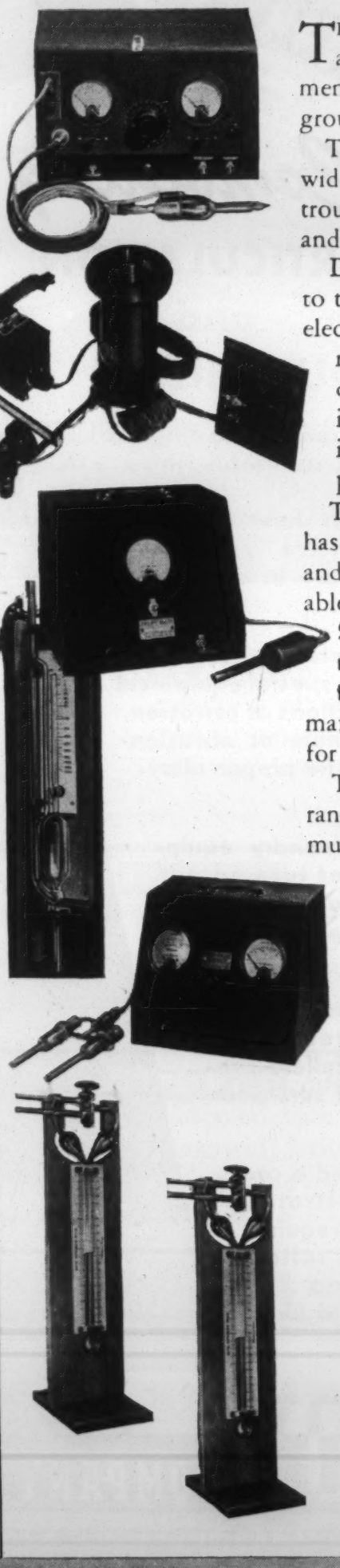
flange mount, open end two guide pin type, and open end three guide pin type. They are standard in 2-, 3-, 4-, 5- and 6-in. dia. and in 1-, 2-, 3-, 4-, 5- and 6-in. stroke lengths.

A feature of the punching unit line is

High Vacuum... make it,

measure it and control it with DPI equipment


10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2}
Ionization Gauge
Radiometer (Knudsen) Gauge
Philips Gauge
Medium Bulb Double Range McLeod Gauge
Pirani Gauge — Compensated at zero
Butyl Phthalate Manometer
Mercury Manometer



TEN years of research, development, design and manufacture of high-vacuum equipment have given DPI a rare technical background in the field.

The tangible result of this experience is DPI's wide variety of highly sensitive yet sturdy, trouble-free apparatus for making, measuring and controlling high vacuum.

DPI high-vacuum engineering is contributing to the production of television tubes and other electronic devices, to vacuum metallurgy and metal evaporation, dehydration, vacuum distillation, atomic energy, and in scores of industries which are just beginning to see in high vacuum a new medium with untold potentialities.

To fit this wide range of applications, DPI has designed and produced more than 35 types and sizes of high-vacuum pumps, and also suitable controls, gauges, valves and accessories. **Seven fine gauges to provide accurate readings of high vacuum are shown on this page.** Each has a different range of maximum sensitivity—thus each is best fitted for a particular range of operation.

The accompanying charts indicate the full range of each instrument. The Range of Maximum Sensitivity is indicated by the widest portions of that line.

For equipment to attain high vacuum, to measure it and to control it, look to DPI—a pioneer in the field of high vacuum. Your questions will be carefully and promptly answered. Write—

DISTILLATION PRODUCTS, INC.

733 Ridge Road West, Rochester 13, N. Y.
570 Lexington Ave., New York 22, N. Y.
135 S. LaSalle St., Chicago 3, Ill.

DPi
HIGH VACUUM RESEARCH AND ENGINEERING

Manufacturers of Molecular Stills and High-Vacuum Equipment; Distillers of Oil-Soluble Vitamins and Other Concentrates for Science and Industry

DURALINK BELT

Combining

ARTICULATION and DURABILITY

It was quite a casting job . . . and an assembly job . . . to make this high alloy belt for a continuous heat treating furnace. But it's typical of the work we are in a position to handle.

1 We have metallurgists capable of designing special equipment to meet conditions of corrosion, high temperature or abrasion and to select the proper alloying elements.

2 We have the foundry equipment capable of turning out sound castings ranging from a pound or two up to six tons per piece.

3 We have the latest in X-ray and Gamma-ray testing apparatus and an excellent control laboratory to be sure your castings are sound.

Possibly you don't need a continuous belt, as illustrated. Perhaps your casting requirement is a retort, grid, roller, pump part, kettle, cap . . . whichever it is, we would like to take care of it for you.

Do you have our General Catalog 4729-G? If not send for a copy.

THE DURALOY COMPANY

Office and Plant: Scottdale, Pa. • *Eastern Office:* 12 East 41st Street, New York 17, N. Y.

Los Angeles & San Francisco: KILSBY & HARMON

F. O. NELSON, 1743 McCormick Building, Chicago, Illinois

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METAL GOODS CORP. St. Louis • Houston • Dallas • Tulsa • New Orleans • Kansas City

New Materials and Equipment

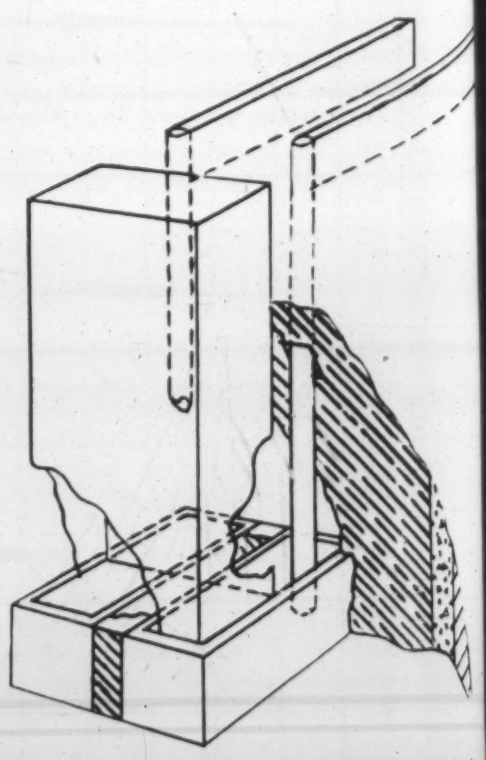
that cylinders are interchangeable on the various types of bases. The pistons are of sleeve construction and therefore provide full length guides during the stroke, which is said to help maintain high precision of punch alignment and permit accurate off-center punching. Other features include rubber-backed, split-ring dual metallic piston seals, and ability to handle working pressures up to 2500 psi.

Use of these punching units for piercing after forming assures proper hole alignment in the finished product and permits complete punching of any part with one set-up in one fixture.

Electrode Replacements Reduced in Molten Bath Furnace

A molten bath furnace utilizing a "liquid" electrode has been developed by the *A. E. Holden Co.,* New Haven 8, Conn. The furnace can have two or more pools separated by a ceramic barrier, and containing an alloy, molten at operating temperatures.

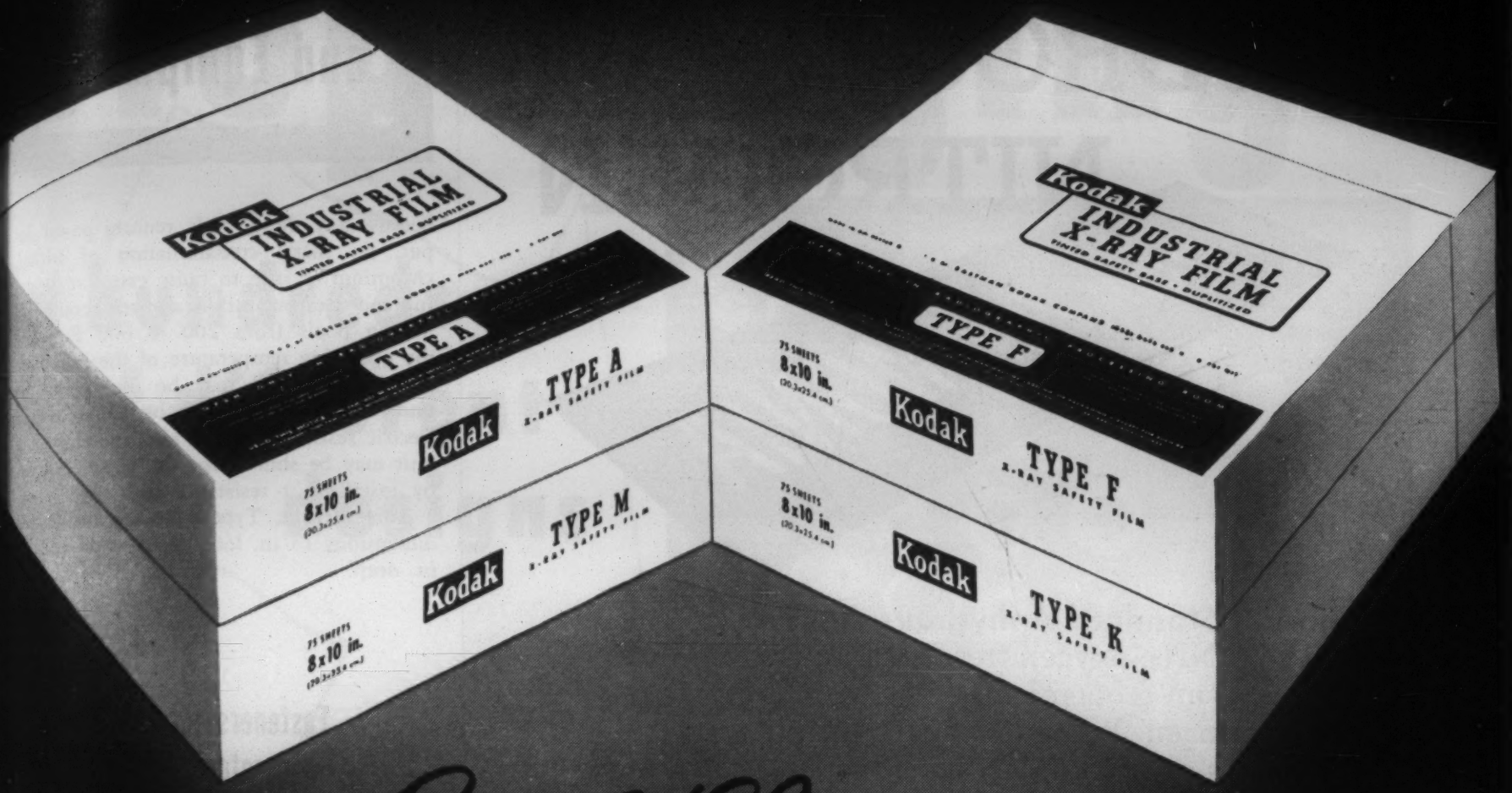
The power conductors that transfer current to the pools containing the liquid alloy



Diagrammatic view of replaceable heating unit showing alloy containers in position and power conductors.

are entirely surrounded by refractory. This, it is claimed, permits reduction in surface radiation area by 25%. Other advantages cited are: power flow through large volume of salt produces fast heating and no salt breakdown, salt bath does not overheat

WHY 4 TYPES OF KODAK INDUSTRIAL X-RAY FILM?



Because

Radiography in industry meets widely varying conditions—differences in density of materials, in size of objects, in type of radiation, and in the capacity of the X-ray equipment available.

No one film, or even two could give best radiographic results under all conditions. So Kodak provides industrial X-ray film in four types.

These afford the choice of speeds, contrast, and graininess that assure dependable, uniform results even under difficult situations.

TYPE M . . . provides highest contrast and exceptional detail under direct exposure or with lead foil screens—has extra fine grain, and speed is adequate for radiography of light alloys at average kilovoltage and for much million-volt work.

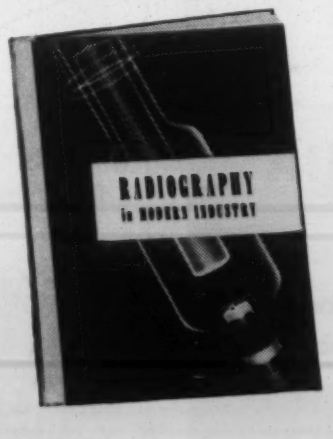
TYPE A . . . has high contrast with greater speed. For study of light alloys at lower voltage than practical with Type M, and at 1000 KV, for heavier parts than the finer grain film permits. Used direct or with lead foil screens.

TYPE F . . . offers highest available speed and contrast when exposed with calcium tungstate intensifying screens. Film has wide latitude with lead screen exposure either to X-rays or gamma rays.

TYPE K . . . has medium contrast. Chosen where speed is important and calcium tungstate intensifying screens are not used. Especially advantageous in studying heavy steel parts by gamma rays, and for the fastest X-ray diffraction exposures.

EASTMAN KODAK COMPANY
X-ray Division, Rochester 4, N. Y.

RADIOGRAPHY IN MODERN INDUSTRY



A wealth of invaluable data on radiographic principles, practice, and technics. Profusely illustrated with photographs, colorful drawings, diagrams, and charts. Get your copy from your local X-ray dealer—price $3.

"Kodak" is a trade-mark

Radiography

. . . another important function of photography

Kodak

HYDROGEN and NITROGEN from AMMONIA

Barrett Standard Anhydrous Ammonia, 99.95% NH_3, oxygen free, with a very low dew point, is an economical source of pure hydrogen and nitrogen. When dissociated, each pound produces approximately 34 cubic feet of hydrogen and 11 cubic feet of nitrogen.

Engineers have discovered many advantages from the use of dissociated anhydrous ammonia in the production of controlled atmospheres in furnaces for bright annealing, clean hardening, copper brazing, sintering, reduction of metallic oxides, atomic hydrogen welding, radio tube sealing and other metal-treating practices. Anhydrous ammonia also has unsurpassed qualities in nitriding of steel, used as ammonia gas or dissociated.

Metallurgists are effecting real economies by using Barrett Standard Anhydrous Ammonia as a replacement for other more expensive sources of hydrogen and nitrogen. For information, contact Barrett, America's leading distributor of ammonia.

Barrett

STANDARD ANHYDROUS AMMONIA

Barrett Standard Anhydrous Ammonia is available in 50, 100 and 150-pound cylinders from stock points located from coast to coast.

THE BARRETT DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 RECTOR STREET, NEW YORK 6, N. Y.

New Materials and Equipment

because any sludge only reduces power input, no metal contamination of nickel, chromium or iron to cause excessive sludging and decarburization, and temperature of molten pools from 200 to 600 F below the operating temperature of the salt bath.

A starting coil may be used with the unit which permits it to be started on an electric resistance circuit and, therefore, the unit may be shut down for power failures by installing a resistance coil.

This furnace, Type 601, has inside pot dimensions 13 in. long, 9 in. wide and 19 in. deep.

Fasteners for High Temperature Service

Bolts, nuts, and other types of fasteners for severe services at elevated temperatures in gas turbines and other highly stressed applications are now available in several high temperature service alloys from the *Franklin C. Wolfe Co.*, 407 Commercial Center St., Beverly Hills, Calif. The fasteners are manufactured by *California Precision Castings, Inc.*, Glendale, Calif.

This line of fasteners is said to have the highest creep properties and short time rupture properties at 1500 F now available

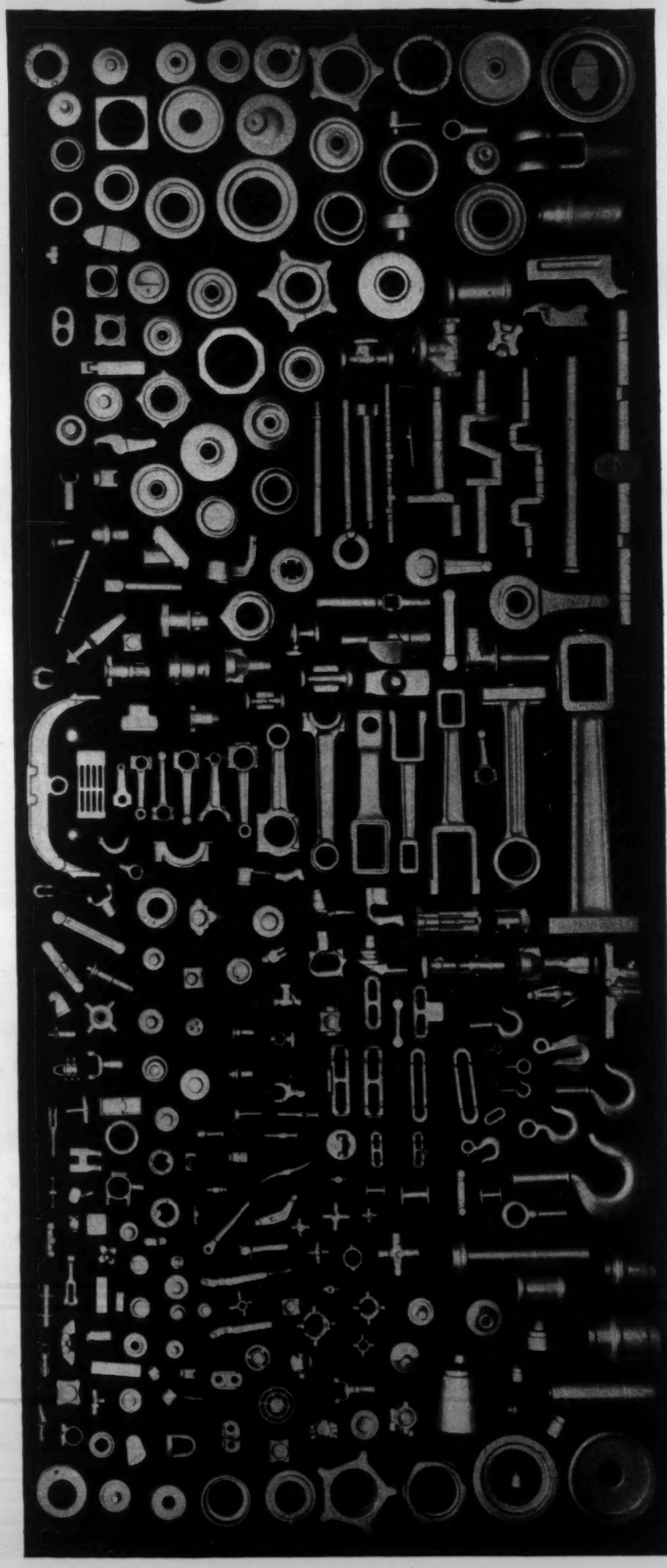
A few types of the high temperature bolts and nuts that are available.

in the form of bolts and nuts. Room temperature strength is 70,000 psi., and strength at 1500 F is 55,000 psi.

They are resistant to oxidizing and reducing atmosphere up to 2100 F. The X-40 Alloy (AMS 5382) fasteners have exhibited the best high temperature endurance properties at 1200 F of all available cast alloys. They are available for SAE thread sizes in internal wrenching socket

Drop Forgings

in hundreds of different designs



These are all Bethlehem drop forgings, and they illustrate the wide range of sizes, shapes, and designs that Bethlehem is equipped to manufacture. Anything here we've made or are making for *you?*

Whenever you're in the market for closed-die forgings, let Bethlehem discuss your needs with you. Our equipment includes steam and board drop hammers, 1500 to 8000 lb; mechanical presses to 2000 tons; upsetters 9 in. and smaller; and a full complement of die-making and heat-treating facilities.

Whether your forged parts require carbon, alloy, or stainless steel, we are well prepared to handle your business. Inquiries will receive prompt, courteous attention.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation
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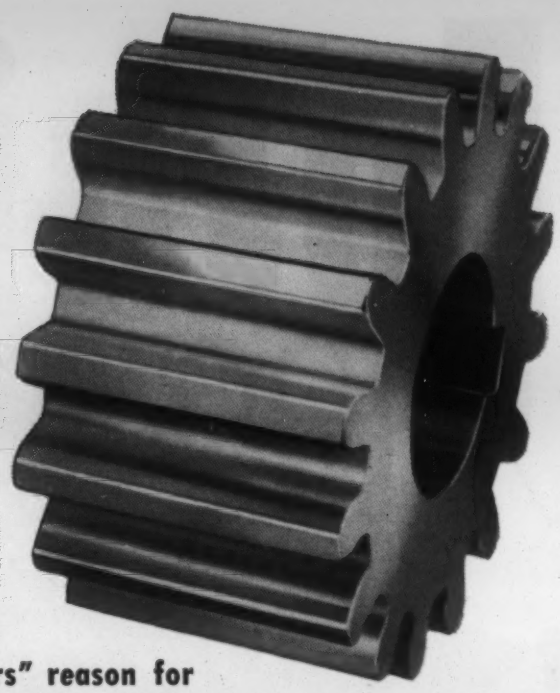
★ BETHLEHEM STEEL ★

Ampco Bronze Gears

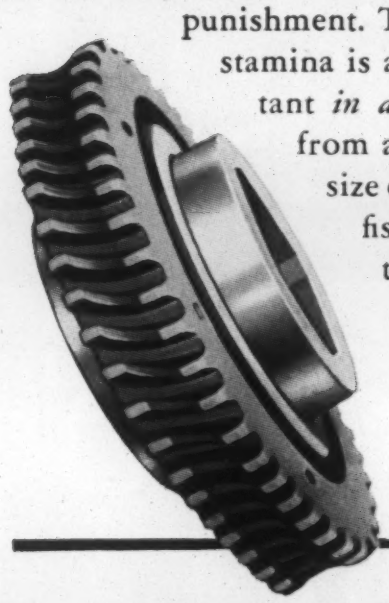


last longer, cut replacement costs

. . . a "common-sense and dollars" reason for making all your gears from Ampco Bronze alloys

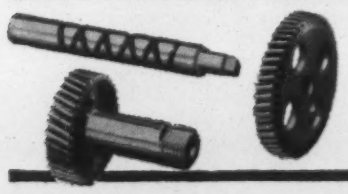
You can count on Ampco Bronze to stand up under the most brutal punishment. This extra stamina is all-important *in any gear*—from a thimble-size drive for a fishing reel to the rolling-mill gear which is illustrated below.

Whether you are designing a new gear or rebuilding old equipment, play safe by selecting the Ampco alloy and form that fit your needs. Get a gear that stands up under impact and fatigue with unbelievable resistance to wear—that outlasts any gear on the same job. Ask your nearest Ampco Field Engineer for recommendations and assistance.

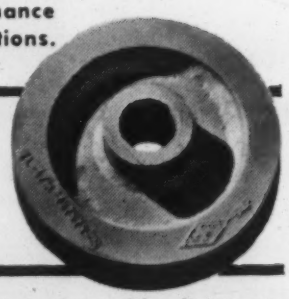


SAND-CAST AMPCO METAL—Massive 2416 lb. worm gear which plays a critical part in the "screw-down" mechanism of a giant size rolling mill.

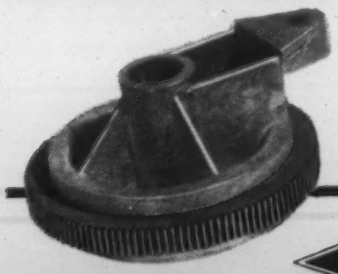
CENTRIFUGAL CASTING (including teeth)—Used as a boom hoist gear on large excavating shovel. Withstands wear, fatigue, shock, and abrasion caused by dust, dirt, and loading.



EXTRUDED AMPCO METAL—Tiny drive-gears and level-wind gears for a fishing reel; designed to give perfect performance and service under widely varied conditions.



WELDED ASSEMBLY — An Ampco centrifugally-cast ring welded to a mild steel hub and web with Ampco-Trode 10.



***CONTINUOUS-CAST AMPCOLOY—Bronze rim with die cast aluminum hub and web. This eccentric gear is proving its value by giving long, satisfactory service in many automatic home washers—and at a savings to the manufacturer.**

*Produced by American Smelting and Refining Co. under a patented process.

Ampco Metal, Inc.

Dept. MA-2 • Milwaukee 4, Wisconsin

Field offices in principal cities. G-1

Detailed information on Ampco Metal and Ampco Bronze alloys

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New Materials and Equipment

head bolts, with or without safety wire holes. Nuts are available in self-locking double 12-point hexagonal. Self-locking plate nuts and special shapes are obtainable in the equivalent to a class three fit.

Flash Trimmers for Strip Stock and Cylindrical Parts

Two new flash trimming machines have been announced by the *Morton Mfg. Co.*, Muskegon Heights, Mich. The one is especially arranged for removing the flash or upset from strip stock or cylinders such as barrel bands or bicycle rims up to 4-in. maximum width and 3/32-in. maximum thickness.

The base of the machine provides the receptical for the hydraulic fluid and operating valves. The lower housing is machined on the upper surface to form the guiding ways for the movable cylinder. Constant cut and return stroke is provided and 1½ in. of vertical movement between the dies is provided for entering and removal of the work. Provisions are made for shortening the total length of ram travel. This trimmer is automatic in its operating cycle, and foot pedal starting is provided.

One of the two new flash trimming machines.

The second trimmer is used in removing the flash or upset from butt welded small motor frames and other cylindrical parts.

Ask Your Alumilite Finisher How

Compacts of aluminum with the lustrous blue color sealed *in* the finish . . . builders' hardware of aluminum with harmonious color and textures . . . any color you want *in* the things you make from Alcoa Aluminum. That's what the patented Alumilite finish can do to give your aluminum products greater beauty, longer life, better sales appeal.

The Alumilite finish gives aluminum a harder surface that withstands abrasion and wear. And Alumilite finishes include a wide variety of colors and textures, natural aluminum, gold, brass, bronze, and other metallic effects.

Ask your nearby licensed Alumilite finisher to show you the colors and finishes he can achieve with the unique Alumilite finish that can be applied only to aluminum. If you don't know the name of the Alumilite licensee nearest you, we'll gladly introduce you. Write to ALUMINUM COMPANY OF AMERICA, 662 Gulf Building, Pittsburgh 19, Pennsylvania. Sales offices in 55 leading cities.

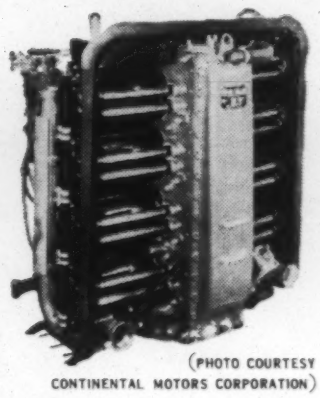
ALCOA FIRST IN ALUMINUM

DC DOW CORNING SILICONES

Silicone News

More Power Per Pound†

Call it plain laziness or call it "divine discontent," some potent force has driven us to seek more concentrated motive power ever since man started to move on wheels. But each increase in horsepower per pound has increased operating temperatures and created a need for more heat resistant materials. Dow Corning Silicones help to supply that need in such major developments as the new air-cooled gasoline engine by Continental Motors Corporation of Detroit.



(PHOTO COURTESY CONTINENTAL MOTORS CORPORATION)

Horsepower per pound in Continental's new line of air-cooled gasoline engines is increased as much as 100% in engines below 250 hp . . . more than 300% (down from 2400 to 777 lbs.) in the horizontally opposed 8 cylinder 250 hp engine shown at left. In this type of engine, Silastic gaskets are essential parts of the standard push-rod and tube assembly.*

Among the many problems solved by Continental engineers in designing this compact power plant, was the leakage of oil around the push-rod tube assembly. Hot oil and operating temperatures up to 500° F. severely limited the life of conventional gasketing materials. Continental engineers, however, knew about Silastic, the rubber-like Silicone by Dow Corning, and they asked for samples and technical assistance.

Silastic solved this problem because it is more heat-stable and more resistant to hot oils and to permanent deformation at temperatures above 200° F. than any other resilient material. Use of engines in sub-zero weather is not restricted by these gaskets of Silastic 161 because they are serviceable from —90° to 500° F. For more information about Silastic, ask for data sheet No. F-5BC.

†See Silicone News, Dec. 1947, for story on 50% reduction in size and weight of electric motors made possible by Dow Corning Silicone Insulation.

*TRADE MARK REGISTERED U. S. PAT. OFF.

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Dow Corning

FIRST IN SILICONES

New Materials and Equipment

It has a capacity of 4½-in. minimum to 9-in. maximum dia., 8-in. length of stroke and stock thickness up to ¼ in. maximum. It is hydraulically operated.

The base of the machine contains the hydraulic fluid and operating valves. The upper column provides machined guider bearing surfaces which form the guiding path for the vertically movable cylinder and tool carriers. The cutting cylinder is of special design, being made with generous rectangular bearing surfaces cast integral with the cylinder housing. The lower cap of the cylinder contains the special relieving clapper box type of tool holder which is provided with horizontal adjustment for positioning the cutting tool in relation to the work clamping dies.

A cutting speed of 50 ft. and return speed of 100 ft. per min. is provided. The work holding and clamping fixture is hydraulically operated. It may be adjusted toward or away from the back clamping dies to take care of variation in work diameters. Automatic operation of clamp, cut, return and unclamp is provided with foot pedal control. The cutting tools are adjustable within the tool holder. Provisions are made for quick removal of the tools for servicing.

● A Swiss precision jig boring machine has been made available by the *Hauser Machine Tool Corp.*, Manhasset, N. Y. A feature of this machine is the centralized control. From the operating position in front of the machine all controls are within convenient reach. Micrometer screws are made of steel and are high-precision ground.

New Finishing and Cleaning Products

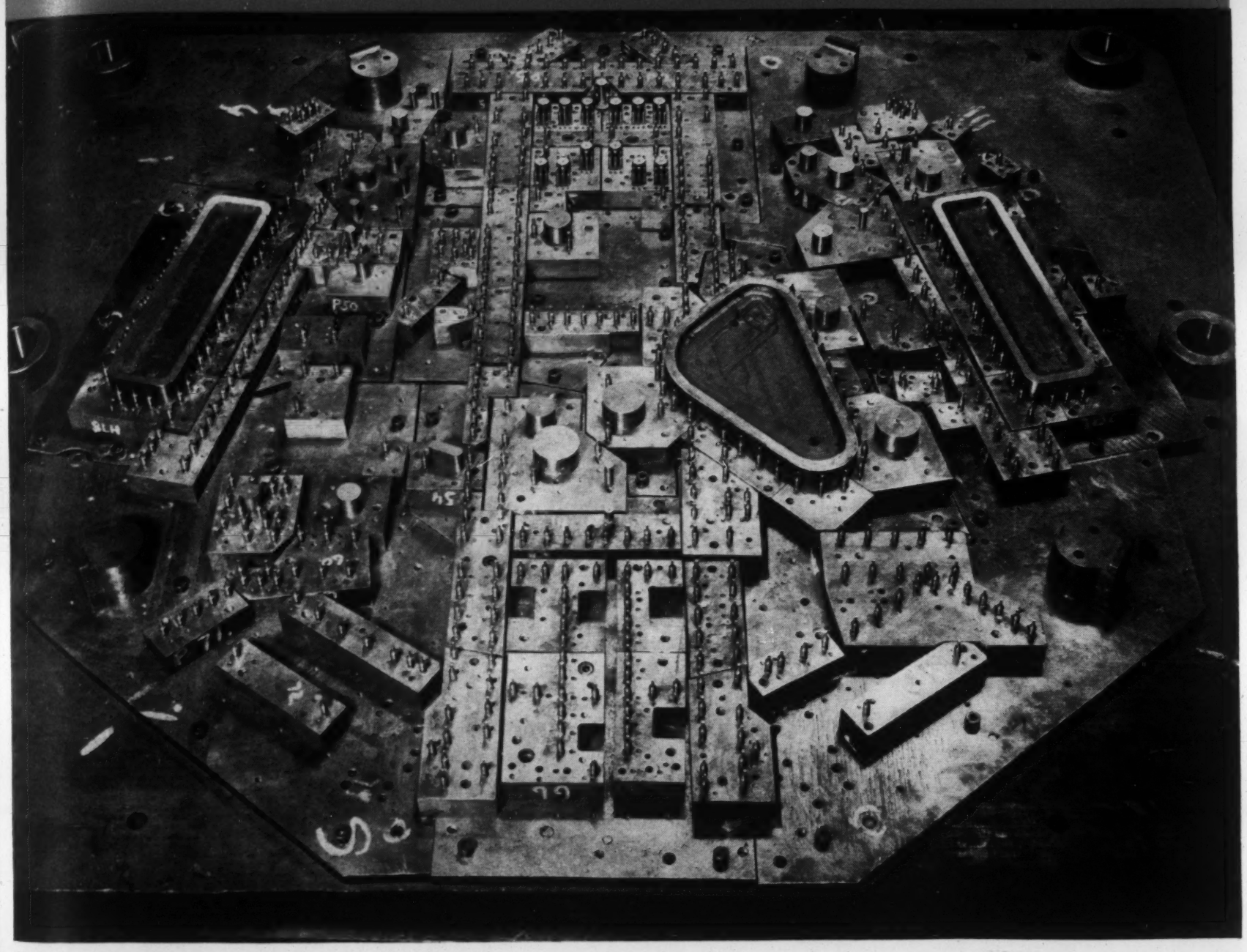
Improved Acid Copper Bath

An improved acid copper bath which makes possible plating speeds up to 0.001 in. in 10 to 15 min., and which is said to eliminate the faults inherent in the original method, has been developed by the *Dayton Bright Copper Co.*, 1030 Valley St., Dayton, Ohio.

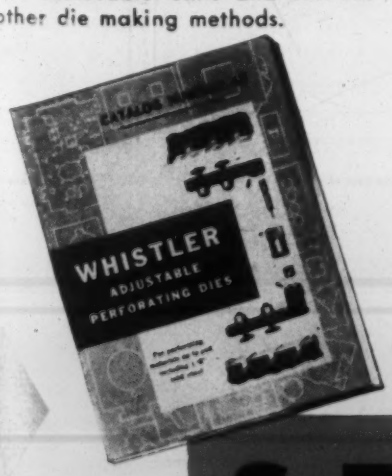
The method, called Daybrite, employs no cyanide or hot baths. It gives off no offensive fumes or odors, therefore requires no ventilation. The bath is reported to give smooth, dense deposits which tend to fill out minor defects in the base metal, increasing corrosion resistance, and simplifying or eliminating buffing operations before the nickel plating cycle. The bath is also suited to

It just doesn't make sense

to tie up manpower and spend money needlessly when there are quicker, more economical ways of doing the same job better.



Here is the punch arrangement of a 70" x 84" Perforating Die set weighing approximately 6 tons. You can see for yourself the cost and production advantages of *removable* units and sections over other die making methods.



Whistler's way of making up precision dies with *removable* parts is now standard practice in hundreds of production and cost-minded metal working plants. Use Whistler drill jigs for drilling the retaining screw holes. Make up your own dies using Whistler *removable* and *interchangeable* punches, dies, strippers and other parts. Round punches and dies from 1/32" to 3" diameters are carried in stock. Special shapes quickly made to order. Prove to yourself the remarkable economies in dollar outlay and days quicker in production. ***Better write us and ask for Catalog No. 48.***

THE BEST KNOWN names in industry have found this catalog very useful

S. B. WHISTLER & SONS, Inc.

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EVEN WHERE SPACE IS LIMITED
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Disc Filters
Originally designed for aircraft, the Hoffman Disc Filter has been adopted and improved for industrial applications. Thus, you can get continuous flow of clean coolant, even in "cramped quarters". First cost is low . . . no moving parts to get out of order . . . minimum maintenance.
MODEL I 6-15 D
5 to 50 g.p.m.
Three sizes of this practical, efficient filter will remove dirt particles measuring from 3 to 5 micro inches. For further details and an estimate of the correct size for your requirements, write today.
NEW LOWER PRICES!
As more and more companies turn to Hoffman Disc Filters, increased production brings you new lower prices. Now in effect—ask us about them.
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1 to 10 g.p.m.
MODEL I 6-90 D
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U. S. HOFFMAN MACHINERY CORPORATION
223 Lamson St., Syracuse, N. Y.
COOLANT FILTERS • FILTRATION ENGINEERING SERVICE

New Materials and Equipment

applications in electroforming operations, particularly the recording industry, because of its inherent fine grain and tensile properties.

Dip Treatment for Zinc

A dip treatment for zinc has been announced by *United Chromium, Inc.*, 51 E. 42 St., New York 17. The compound, known as Unichrome Dip Compound 95, is used to produce corrosion-resisting conversion coatings on hot dipped zinc, plated zinc, and zinc die castings. Depending on the degree to which the compound is diluted, one of the following finishes is produced: (1) on zinc plate, a clear bright finish that looks like chromium or an olive drab finish; (2) on zinc die castings, a clear, bluish finish or an olive drab finish; (3) on hot dipped zinc, a bright spangled finish or an olive drab one; and (4) on all zinc, a coating which serves as an excellent base for paint, lacquer, or enamel.

The process is said to be good for finishing wire goods, small parts, and parts on which it is economically impossible to deposit enough copper, nickel and chromium to provide the necessary corrosion resistance. Typical of the parts now being given the bright, chromium-appearing finish are ice skates, refrigerator shelves, screws, hinges, and fan guards. Parts being processed in the olive drab finish include die cast automotive fuel pumps and carburetor bodies.

Black Finish for Aluminum

The *Duralac Chemical Corp.*, 84 Lister Ave., Newark, N. J., has announced the availability of its new finish, Adheron Satin Black. This finish can be used as a primer under nitrocellulose lacquer or under synthetic baked finishes, or it can be used as a satin or semi-gloss finish for aluminum and other nonferrous metals.

Combination Pretreatment and Primer

To eliminate the necessity of having to remove all rust or to have the surface perfectly dry before painting, a combination chemical pretreatment and primer for metal, Rust-O-Primer, has been developed by the *Wilbur & Williams Co.*, Greenleaf & Leon Sts., Boston 15, Mass. This vinyl-base, quick drying wet primer is applicable over wet or dry, clean or rusted metal, including steel, aluminum or galvanizing. Its purpose is to provide a hard, paintable foundation for any type of paints, including ship-bottom paints as well as vinyl type of finish.

Resin for Baking Enamels

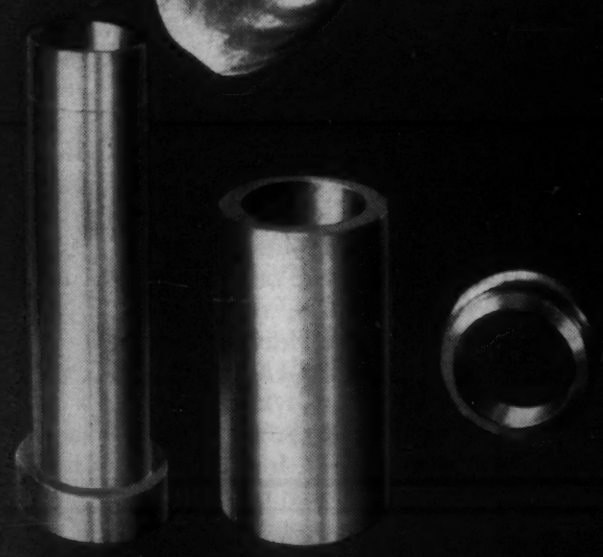
Fast curing speed, good gloss, and good stability with high viscosity characteristics are claimed for the melamine formaldehyde resin introduced by *Rohm & Haas Co.*, Washington Square, Philadelphia 5. This permits the production of baking enamels

[illegible] TO DISTRIBUTORS: Write us about [illegible] Standard Tools in your territory.

What [illegible]s have you for CARMET to do?

In addition to a most complete line of Carmet cutting [illegible] blanks, we are equipped to make pre-formed [illegible] carbides to practically *any* specifica- [illegible] size, shape or tolerance—furnished plain [illegible]. ● Solve that "problem-part" of [illegible] *an Allegheny Ludlum Tool Engineer.*

ADDRESS DEPT. MM-72



[illegible]'s an Example!
[illegible]er, Bearing and
[illegible]g Die, made of
[illegible]MET Carbide

AL

Allegheny Ludlum Tool Corporation

CARBIDE ALLOYS DIVISION, Ferndale (Detroit) Michigan

MAKE YOUR PRODUCT FULLY NON-CORROSIVE!

STAINLESS STEEL SCREWS

IMMEDIATE DELIVERY

Machine, Self-tapping Socket, Set, Wood Screws. Also Nuts, Bolts, Washers, Rivets, Pins—all types and sizes—delivered immediately from America's largest stock.

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For Catalog No. 49E, write today, on your letterhead.

STAINLESS STEEL FASTENERS

MANUFACTURERS SINCE 1929

ALLMETAL Screw Products Co., Inc.

33 GREENE STREET, NEW YORK 13, N. Y.

Char-Lynn ALUMINUM DIE CASTINGS

By a special Char-Lynn process, heavy section castings can be produced without porosity. Fast, accurate Reed-Prentice machines, manned by able craftsmen, turn out castings of quality. You are assured of permanence of dimension and shape . . . good surface finish . . . time and money saved in your finishing department. *Write or phone for engineering consultation and estimates.*

LARGEST IN THE UPPER MIDWEST . . .

Up to 6 pound capacity

CHAR-LYNN COMPANY

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New Materials and Equipment

with lower solids content. The resin, known as Uformite MM-55HU, imparts its characteristics to baking enamels when blended with urea resins. This resin is suggested for use as a general-purpose melamine formaldehyde resin in white industrial baking enamels for application to refrigerators, kitchen cabinets, metal signs, etc.

Combination Cleaner and Coating Compound

A new cleaning and phosphate coating material for use on steel and other ferrous metals to provide a fine base for paint coating has been placed on the market by the *Detrex Corp.*, Detroit 32. This material, known as Detrex 79, is a yellow, non-corrosive cleaning compound in dust-free powder form. It is used in heated water solutions at low concentrations for the production of a light crystalline phosphate film on metal parts.

No special equipment is required for application as the solution can be used in open tanks or continuous washing machines, especially of the spray type—either single or multiple stage. The coating is done in a minimum of time and space requirements for equipment. In addition to being fast, it is said to be economical and safe (there are no fumes or other hazards). The time required in either mechanical or still tank processing is 1-min. spray contact or immersion for a desirable phosphate coating. The parts come from the process with a clean water-wet surface that dries to a typical uniform blue-gray finish, either in the air or a blow-off stage following the cleaning-coating process.

Strippers for Organic Finishes

Two new room temperature strippers for synthetic enamels are now being marketed by *Enthone, Inc.*, 442 Elm St., Dept. MA, New Haven, Conn. They have been named Stripper S-17 and Stripper S-19.

Stripper S-17 is a clear, quick-evaporating stripper used at room temperature for removal of all types of synthetic enamels, including heavy coatings of enamels that accumulate on work holders and hooks. For such cases, the various layers of enamel exfoliate, leaving the work holders clean. This stripper is suggested for the removal of clear synthetic enamels from highly polished surfaces, such as brass, gold plate and silver. It does not tarnish metals and it has no significant odor.

The other stripper is similar to S-17 in its action and appearance, except that it is slightly ammoniacal in composition and is used in certain special cases for removal of synthetic enamels where S-17 is not satisfactory. Both strippers are used with water seals to minimize evaporating losses, and rinsing is not necessary after the use of these strippers.

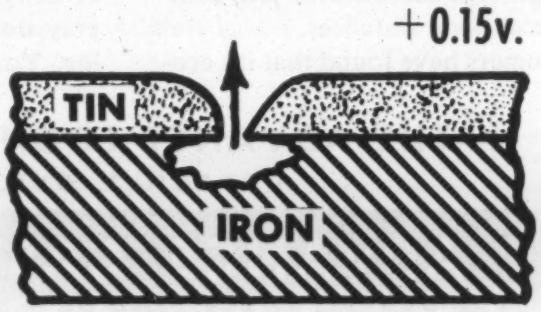
(Continued on page 122)

MECHANISM OF PROTECTIVE ACTION IN *Galvanizing*

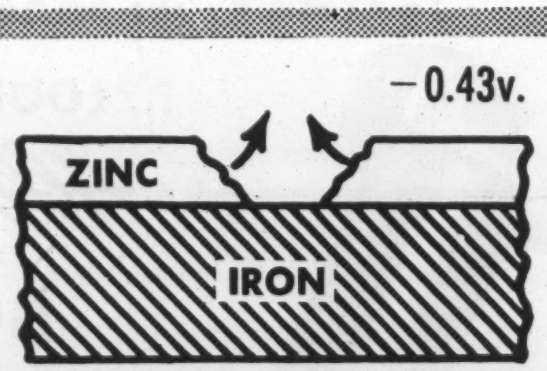
VOLTS:

Vs. H_2		Vs. Iron
+ 1.08	Gold	+ 1.42
+ 0.86	Platinum	+ 1.20
+ 0.77	Silver	+ 1.10
+ 0.34	Copper	+ 0.68
0	Hydrogen	+ 0.34
— 0.15	Lead	+ 0.19
— 0.19	Tin	+ 0.15
— 0.23	Nickel	+ 0.11
— 0.34	Iron	0
— 0.42	Cadmium	— 0.08
— 0.50	Chromium	— 0.16
— 0.59	80% Zn, 20% Fe	— 0.25
— 0.65	90% Zn, 10% Fe	— 0.31
— 0.77	Zinc	— 0.43
— 1.28	Aluminum	— 0.94

Electromotive Series from *GALVANIZING HANDBOOK*, J. R. Daesen



I. *Metal positive to Iron*

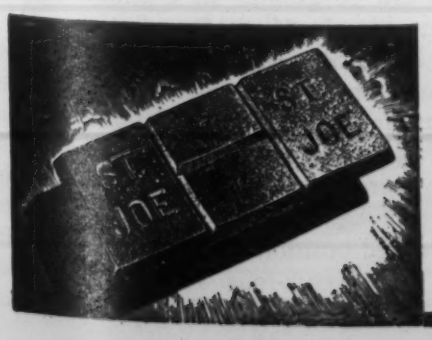


II. *Metal negative to Iron*

IRON AND STEEL products are galvanized, or coated with zinc, in order to prevent rusting. Rusting is an electrochemical action in which iron replaces hydrogen, or a metal, in a dilute electrolyte — a solution which conducts electricity. The presence of carbon dioxide, sulfur oxides and small amounts of salt make the moisture in the air such an electrolyte.

Each metal or alloy has its own definite activity, or ability to replace hydrogen or other metals in electrolytes; this property is termed its electro-potential. A list of the metals arranged in increasing order of activity, with their electro-potential expressed in volts, is called the Electromotive Series. The voltage figures at the left-hand side of the table, for example, show that a force of 0.34 volt is the cause of the replacement of hydrogen from an acid solution by iron. Zinc, being far more active, a force of 0.77 volt acts to drive hydrogen out of an acid solution. For convenience, the zero point has been placed at iron and the figures, since they are relative only, have been transposed to show — at the right-hand side of the table — the activity of the metals relative to iron. Tin, for example, has less tendency to go into solution, and therefor rust, than iron, while in zinc the tendency is greater. This property of zinc is the reason why it is preferred as a protective coating for iron and steel.

For economic or mechanical reasons, the protective coating should be thin, and a thin coating is apt to be imperfect due to scratches, pits and other breaks in the surface. At these openings the corrosive electrolyte comes in contact with the iron and the coating metal. If the coating metal is tin, as in Figure I, a positive potential of 0.15 volt causes the *iron* to move into solution while the tin, being less active, has no tendency to dissolve. If the coating metal is zinc however, as in Figure II, a negative potential of 0.43 volt pulls the *zinc* into solution; there is no tendency at all for the exposed iron to dissolve or rust while any zinc remains near the break in the surface. This "sacrificial" protective action by zinc is the main reason for its universal adoption for the rust-proofing of iron and steel products. In 1947, 359,583 tons of zinc, representing 46% of all the zinc consumed in the United States, has been used for galvanizing.



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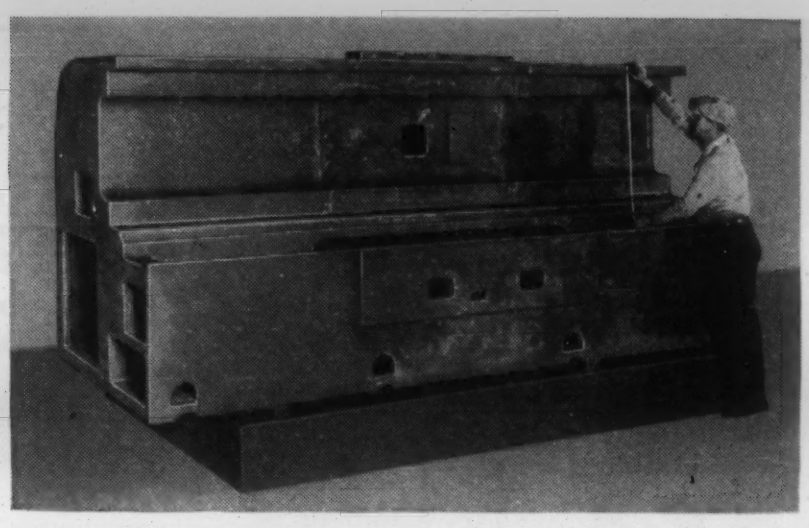
250 PARK AVENUE, NEW YORK 17, N.Y. • ELdorado 5-3200
ST. JOE *Electro Thermic* ZINC
HIGH GRADE • INTERMEDIATE • BRASS SPECIAL • PRIME WESTERN



MACHINE-SHOP LOSSES COST MORE THAN CASTINGS

Pictured above is a ten-ton Advance casting for the bed of a broach grinder If such a casting contained interior defects, the job would have to be welded or scrapped after hours of expensive machine time had been spent on it.

Many shops are searching for predictable castings. This accounts for jobs coming to us from long distances.

Our customers have found that it's economical to pay the freight on Advance castings to save the grief and expense of running into blowholes, cold shuts, cracks, and other obstacles to machining.

For many years we have specialized on *Strenes Metal* cast dies which require soundness and accuracy of the highest order. We maintain the same standard on gray iron and alloy castings for machining. You are invited to consult with us.

THE ADVANCE FOUNDRY CO.
DAYTON 3, OHIO

ADVANCE CASTINGS
STRENES METAL • ALLOY GRAY IRON • GRAY IRON

USE HEADED AND THREADED FASTENERS FOR ECONOMY AND RELIABILITY

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Alloy Steel
BOLTS
and
STUDS

We fabricate every standard alloy steel into bolts, studs and many special fastenings. Accurately made in standard dimensions or to meet your specifications.

BETTER BOLTS SINCE 1882—
A full line in carbon steel, heat-treated alloy steels, stainless steel, silicon bronze, brass, bronze, and monel metal.

"THE BOLT MAN"

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THE PLACE TO SOLVE YOUR BOLT PROBLEMS

New Materials and Equipment

The work to be stripped is merely immersed in the strippers at room temperature. After a few seconds to several minutes, the enamel is completely removed from the surface of the metal and the parts can be removed. The stripper evaporates quickly and the part is ready for refinishing.

Alkaline Cleaning Compounds

Two alkaline metal cleaning compounds, Terj and Ferro-Terj, have been announced by the *DuBois Co.*, Cincinnati 3, Ohio. Terj is a metal cleaner designed for removing light shop soils and for use in industrial washers when cleaning aluminum. It is said not to pit, corrode or discolor aluminum when used in a spray washer. The other, a heavy-duty metal cleaner, is designed to remove tenacious soils such as drawing compounds from steel parts. It is claimed to be the first completely solventized detergent for use on ferrous metals.

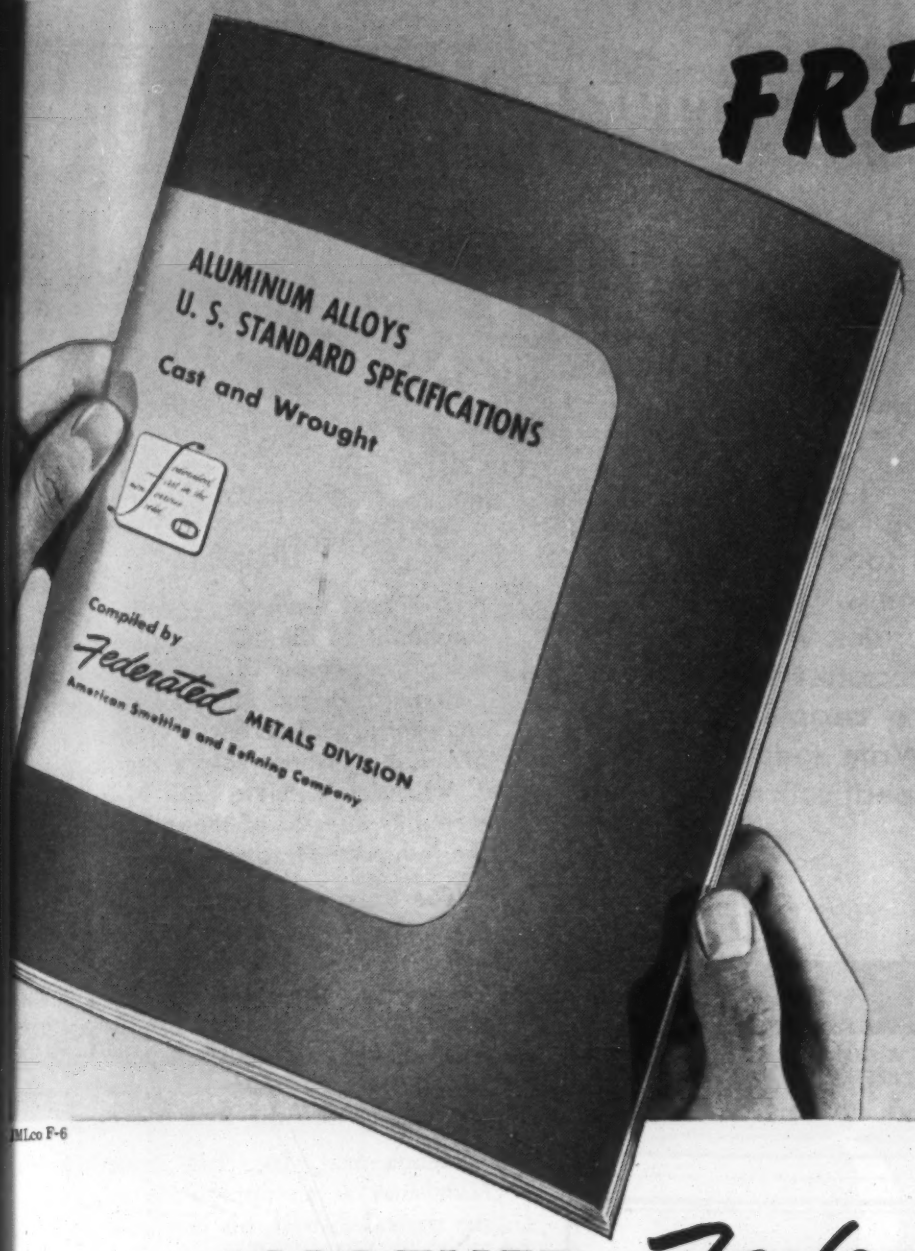
Both cleaning compounds are free-rinsing and leave no deposits on finished work to interfere with subsequent painting or plating operations.

Water Soluble Buffing Compounds

The *Hanson-Van Winkle-Munning Co.*, Matawan, N. J., has developed two compositions, 2-S-10 and 2-S-12, for the plating industry. They are said to have good water dispersible properties as well as good working properties. However, it must be pointed out that while the performance characteristics are good, the cutting properties and composition and buff "mileage" do not quite equal the best in this company's standard group. They will be useful on work where the composition tends to pack; also where the performance is good and the main need is ease of cleaning.

The composition 2-S-10 is for the heavier-duty jobs where more cut is required and maximum solubility is not the primary prerequisite. Composition 2-S-10 is very dry and should be used on filigreed work and the like where cleaning is a real problem and heavy cut not so essential.

● All types of regular and irregular contours can be ground on a grinding fixture designed by the *Harig Manufacturing Corp.*, 319 N. Albany Ave., Chicago 12. Many irregular shapes concentric with shank can be ground within ±0.0002. Adjustable stops permit swing to any number of desired degrees. V-block located in T-slot in center of index plate can be adjusted to any desired position within ±0.0002. Index plate has twenty-four 15-deg. graduations with ±0.0002 accuracy.



FREE Handbook of Aluminum Specifications

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Federated Metals, division of American Smelting and Refining Company
120 Broadway, New York 5, N. Y.

Please send me a copy of the Aluminum Specifications Hand Book.

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Company Name _____

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IMLco F-6

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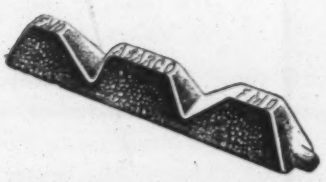

For your convenience . . . here in one 24-page volume . . . are all the latest specifications of the aluminum industry—ASTM, AMS, SAE, Federal, Army, Navy and others—as they pertain to Sand Castings, Permanent Mold Castings, Die Castings, Wrought Alloys and Ingots.

This 24-page book is *not* a sales manual. There is no talk in it about the nationwide production, research, and service facilities of Federated which make this company first in the non-ferrous field . . . no facts which prove that Federated's scientific production control and friendly, on-the-spot help with foundry problems mean more satisfactory and profitable products for *you*.

This Aluminum Alloys Specifications manual is a reference book . . . *a must* for your top desk drawer. It's another Federated first . . . another Federated service. Mail the coupon today for your free copy.

Federated Metals produces aluminum alloys of all specifications, as well as copper-base alloys, bearing metals, solders, magnesium alloys, fabricated lead products, zinc dust, deoxidizers and hardeners. 24 offices across the nation.

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Division of American Smelting and Refining Company, 120 Broadway, New York 5, N. Y.

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News of...

ENGINEERS COMPANIES SOCIETIES

Engineers

J. Wesley Cable has opened offices as a consultant to the high frequency heating field, specializing in both induction and dielectric heating, and offering complete engineering and design service to industry. Mr. Cable, whose offices are located at 325 E. 41st St., New York 17, previously served as director of research and sales of the Induction Heating Corp.

The appointment of Dr. *Maurice H. Bigelow* as technical director of the Plaskon Div. of the Libbey-Owens-Ford Glass Co. has just been announced. Dr. Bigelow, who will have full responsibility for both technical service and research activities, replaces Dr. *William C. Dearing*, who resigned to join the Behr-Manning Corp.

Kennametal, Inc. has named *Robert Hutchison* as an application engineer in the central district, his headquarters to be in the Cleveland office.

G. W. Merrefield has been appointed to the position of consulting engineer to the foundry industry by the firm of Giffels & Vallet, Inc.

The appointment of *William A. Beatty* as manager of the Feeder Div. of the Westinghouse Electric Corp. occurred recently. Mr. Beatty had been superintendent in the Feeder Div. and then manager of manufacturing.

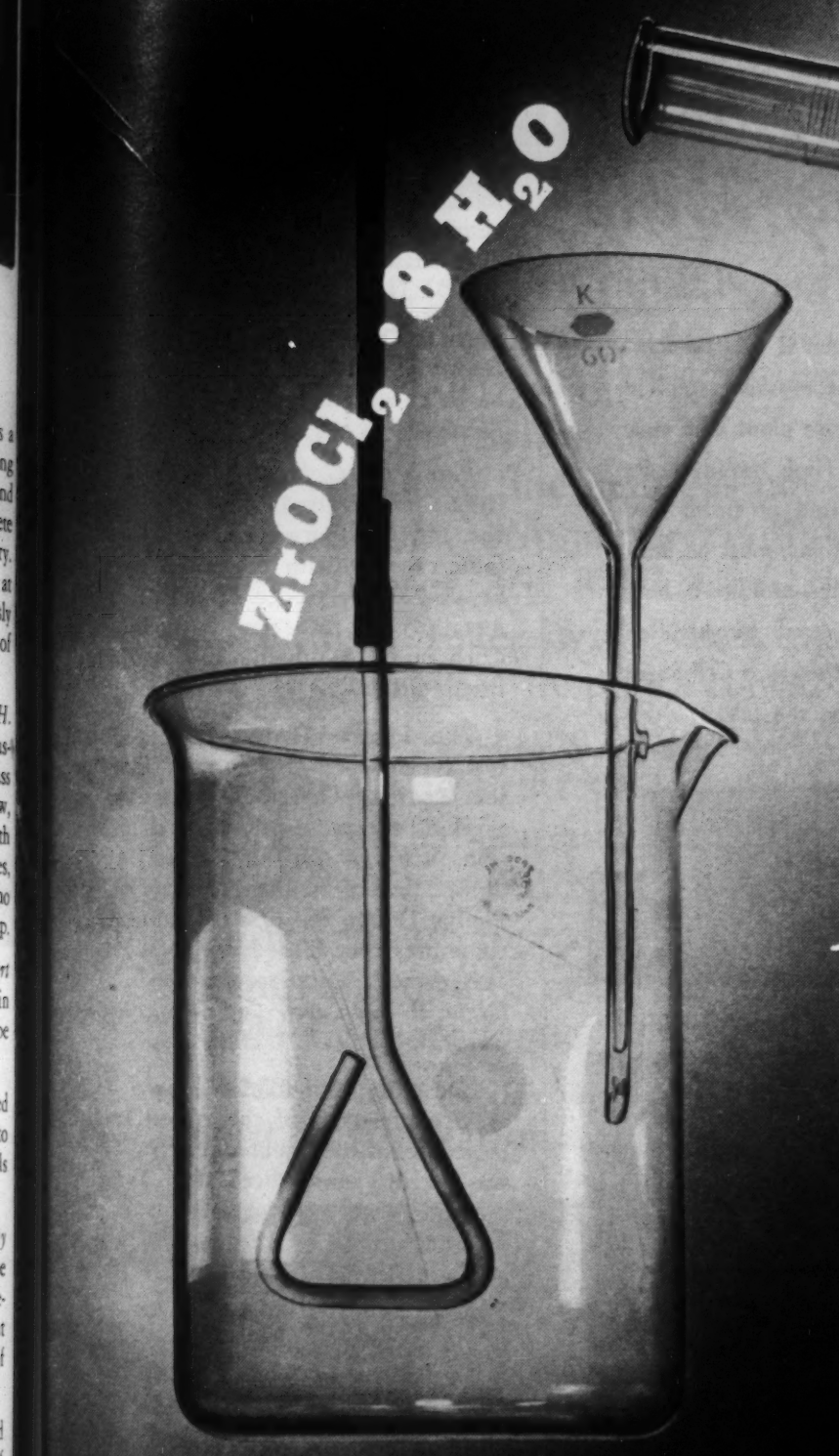
Thomas A. Edison, Inc. has promoted *Richard M. Somers* to the position of chief engineer of its Ediphone Div. Mr. Somers succeeds *Samuel G. Langley*, who will assume the duties of consulting engineer to the division. *Henry S. Carlson* becomes assistant chief engineer, Mr. Somers' former position.

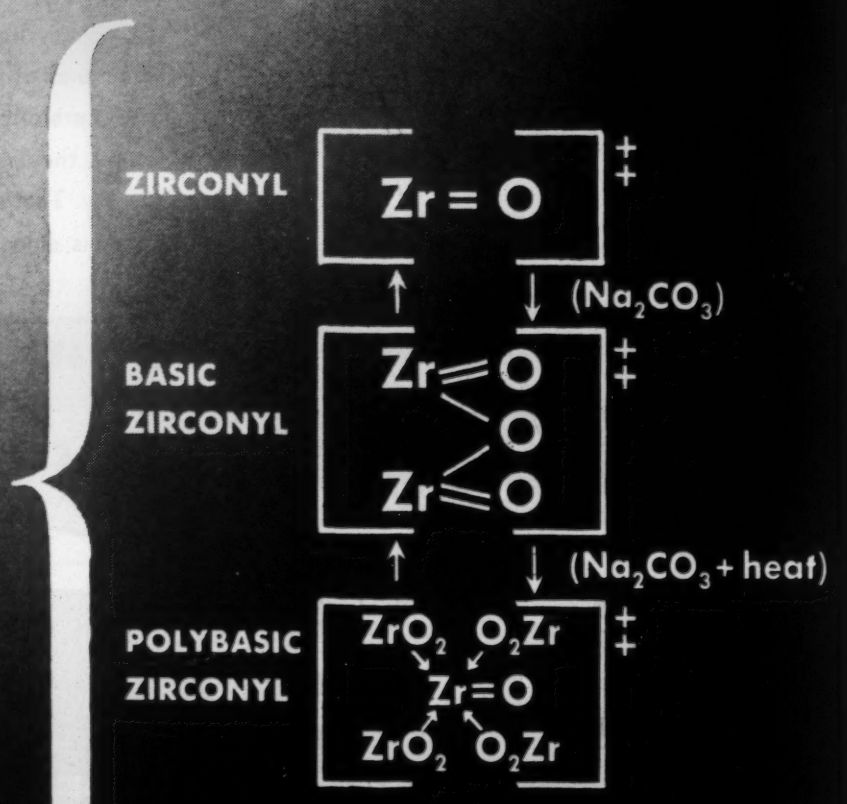
Norman C. Michels has been named manager of operations of the Laclede-Christy Co. and its subsidiaries. He will have complete charge of all manufacturing and mining operations.

The new director of the Midwest Research Institute is Dr. *George E. Ziegler*, who has been acting chief administrator of the Institute since the resignation of *Harold Vagtborg*. Dr. Ziegler's assistant will be Dr. *Clayton A. Dohrenwend*, formerly research consultant of the Institute.

Several new appointments in the Chemicals Div. of the General Electric Co.'s Chemical Dept. include *H. Arthur Howe*, manager of the Pittsfield phenolic prod-

UNUSUAL IONS WITH USEFUL APPLICATIONS





Upon dissolving zirconium oxychloride in water, a number of ionic individuals is obtained. The preponderance of particular ions can be easily controlled by adjusting the temperature and pH of the solution. This permits a surprising number of physical and chemical properties to be realized from this one zirconium salt. These properties have already been successfully exploited in the preparation of a wide variety of chemical products. Many additional uses are in prospect.

Manufacturers interested in better catalysts, mordants, pigment lakes and toners, leather tanning, pharmaceuticals and numerous other chemical products may obtain detailed information through our New York Office.

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Here's a 10 ton C-F Lifter handling bundles of sheet steel in a Westinghouse plant with ease and safety. High grade sheets like these, used in stator and rotor laminations, must be handled carefully—and in a busy plant, they must be handled quickly. That's why a C-F Sheet Lifter is doing the job.

C-F Lifters are made in manual or motor models in capacities from 2 to 60 tons or larger, in standard or semi-special designs. Write for the illustrated bulletin "C-F Lifters"—it may help solve a tough materials handling problem for you.

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EBONOL-S. A one-bath method of blackening steel. Temperature 285 to 290° F. Simple to use and pleasant to run.

EBONOL-Z. A simple process for blackening zinc plate and zinc base diecastings. Beautiful glossy or dull finishes are achieved at low cost and trouble-free operation.

NEW TUMBLING TECHNIQUES are available for blackening and coloring. Send samples for free finishing demonstrations together with advice of experienced research chemists. **Write for new literature with procedures.**

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News of...

ENGINEERS COMPANIES SOCIETIES

ucts plant and the Coshocton, Ohio, varnish plant; *Wyman Goss,* section engineer in charge of engineering on phenolic resins and compounds; and *J. Rae Stirrat,* sales manager of phenolic products.

The board of directors of the Adamas Carbide Corp. recently elected *Edward L. Dreyer* a vice president. Mr. Dreyer will be in charge of sales and advertising for Adamas.

Perry D. Goldberg has been named chief metallurgist of the Pufahl Foundry, Inc. Mr. Goldberg formerly served in the same capacity with the South Park Foundry & Manufacturing Co. and as assistant metallurgist for the Houdaille-Hershey Corp. on the Manhattan Engineer's Atomic Bomb Project.

The Phelps Dodge Copper Products Corp. elected *Wylie Brown* chairman of the Board of Directors. He will continue as chief executive officer of the Corporation. *Whipple Jacobs,* formerly president of the Belden Manufacturing Co., joined Phelps Dodge the first of January, to become president. Three vice presidents were also named. They are *Henry L. Marion, Edgar P. Dunlaevy* and *Weightman Edwards.*

The appointment of *Maynard B. Terry* as vice president of the American Brakeblok Div. of the American Brake Shoe Co. was recently announced. Mr. Terry, who previously was general sales manager, will continue to be located at the Division's headquarters in Detroit.

Three additional members were recently added to the Atomic Energy Commission's Advisory Committee on Raw Materials. They include *Walter O. Snelling,* consulting chemist and director of research of the Trojan Powder Co.; *Thorold Field,* a consulting mining engineer associated chiefly with the Congdon Office of Duluth, and with Case, Pomeroy & Co., Inc. of New York City; and *Orvil R. Whitaker,* who has an independent consulting mining engineer practice in Denver, Colo. Dr. *Donald H. McLaughlin,* president of the Homestake Mining Co., is chairman of the Committee.

The Hydraulic Press Manufacturing Co. announces the appointment of *George A. Daniels* as secretary and treasurer. Mr. Daniels, formerly controller of the company, succeeds *W. C. Batchelor,* who resigned after 33 years of service at H-P-M.

A new member of the board of trustees of Battelle Memorial Institute is Dr. *Frank B. Jewett,* who fills the vacancy created by the death of Dr. *Rolland C. Allen.* Dr. Jewett was formerly chairman of the board of the Bell Telephone Laboratories and president of the National Academy of Sciences.

6000#/hr. of Copper Alloy Strip 26" wide x .025" Continuously Annealed in Drever Vertical Furnace

Furnace annealing capacity of copper alloy strip ranges from 3100 lb/hr of .0035" to 6500 lb/hr of .050" strip.

The complete line includes pay-off mechanism, strip joiner, continuous degreaser, 360 K.W. vertical annealing furnace with charging and discharging loopers, continuous flash pickling equipment (both acid and bichromate tanks), recoiler mechanism and controlled atmosphere generator.

Continuous annealing of both ferrous and non-ferrous strip offers production economies and a consistently uniform anneal which merit investigation.

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FAST ALUMINUM CLEANING

Leading aluminum processors use Metso Granular because it degreases quickly. In some instances, immersion time is as short as 2½ seconds. Besides that, most aluminum must not be harmed, and here, Metso's unique controlling component, soluble silica, prevents strong etching of the sensitive metal.

Where parts must be given longer exposures, at very high concentrations in the cleaning baths, Metso Granular cleaner is further buffered with our "G" Silicate. Send us your inquiries on cleaning aluminum. Full information on Metso Cleaners and PQ Soluble Silicates on request.

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PQ SILICATES FOR FABRICATING METAL CLEANERS

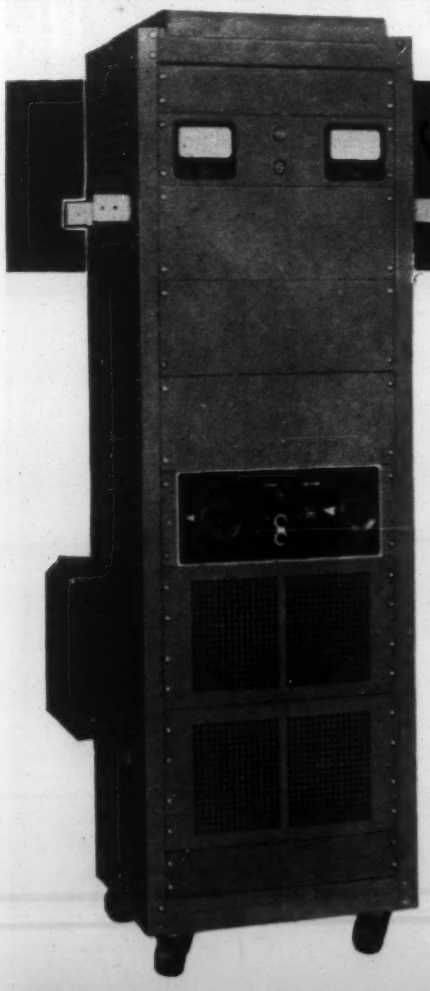
Metso Granular
($Na_2SiO_3.5H_2O$) Sodium Metasilicate. Free-flowing, white granular product.

Metso 99
($Na_3HSiO_4.5H_2O$) Sodium Sesquisilicate. White, granular, free-flowing.

G-C Brand
($Na_20.2SiO_2$) Powdered Sodium Silicate. Hydrated, alkaline. Readily soluble.

G Silicate
($Na_20.3.22SiO_2$) Hydrated powdered sodium silicate (sometimes referred to as trisilicate), rapidly soluble.

Sodium Sesquisilicate U. S. Pat. 1948730, 2145749 • Sodium Metasilicate U. S. Pat. 1898707



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The Green Electric line of Rectifiers, for supplying D.C. power, includes over two hundred standard types ranging from 6 volts to 60 volts and from 25 amperes to 5,000 amperes.

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News of...

ENGINEERS COMPANIES SOCIETIES

Creation of a new vice presidency of Allegheny Ludlum Steel Corp. and the appointment of *Robert M. Arnold*, a director, to the position was recently announced. Mr. Arnold is also president of Arnold Engineering Co., a wholly owned subsidiary.

Dr. *Mary Baeyertz* has been named assistant chairman of the Metals Research Dept. of Armour Research Foundation of the Illinois Institute of Technology. Dr. Baeyertz, author of the recently published book "Nonmetallic Inclusions in Steel", previously served the Foundation as a senior metallurgist.

The Chase Brass & Copper Co., Inc. has elected *Wallace C. Husted* executive vice president, a position which has not been filled since it was relinquished by Charles E. Hart in 1942, the year he became president of Chase. Mr. Husted formerly was vice president in charge of plant operations and organization of the company.

Dr. *William Lee Davidson*, an international authority on atomic energy, has been named director of the Physical Research Dept. of the B. F. Goodrich Co.

The election of *Frank O. Lincoln* as chairman of the board of the Hy-Pro Tool Co., a subsidiary of the Continental Screw Co., has been announced.

A number of appointments at Holcroft & Co. included that of *Ruel T. Cadwell* as president, formerly secretary-treasurer. Mr. Cadwell succeeds *Charles T. Holcroft*, founder of the company, who will remain as secretary and consultant on problems of furnace design. *Walter H. Holcroft* is now executive vice president, *C. H. Martin* has become vice president in charge of the Chicago office, *Robert H. Cadwell* is treasurer, and *A. W. Criger* was named assistant secretary.

The retirement of *George R. Gibbons*, senior vice president and director of the Aluminum Co. of America, was recently announced. He will continue as a member of the board of directors of the company.

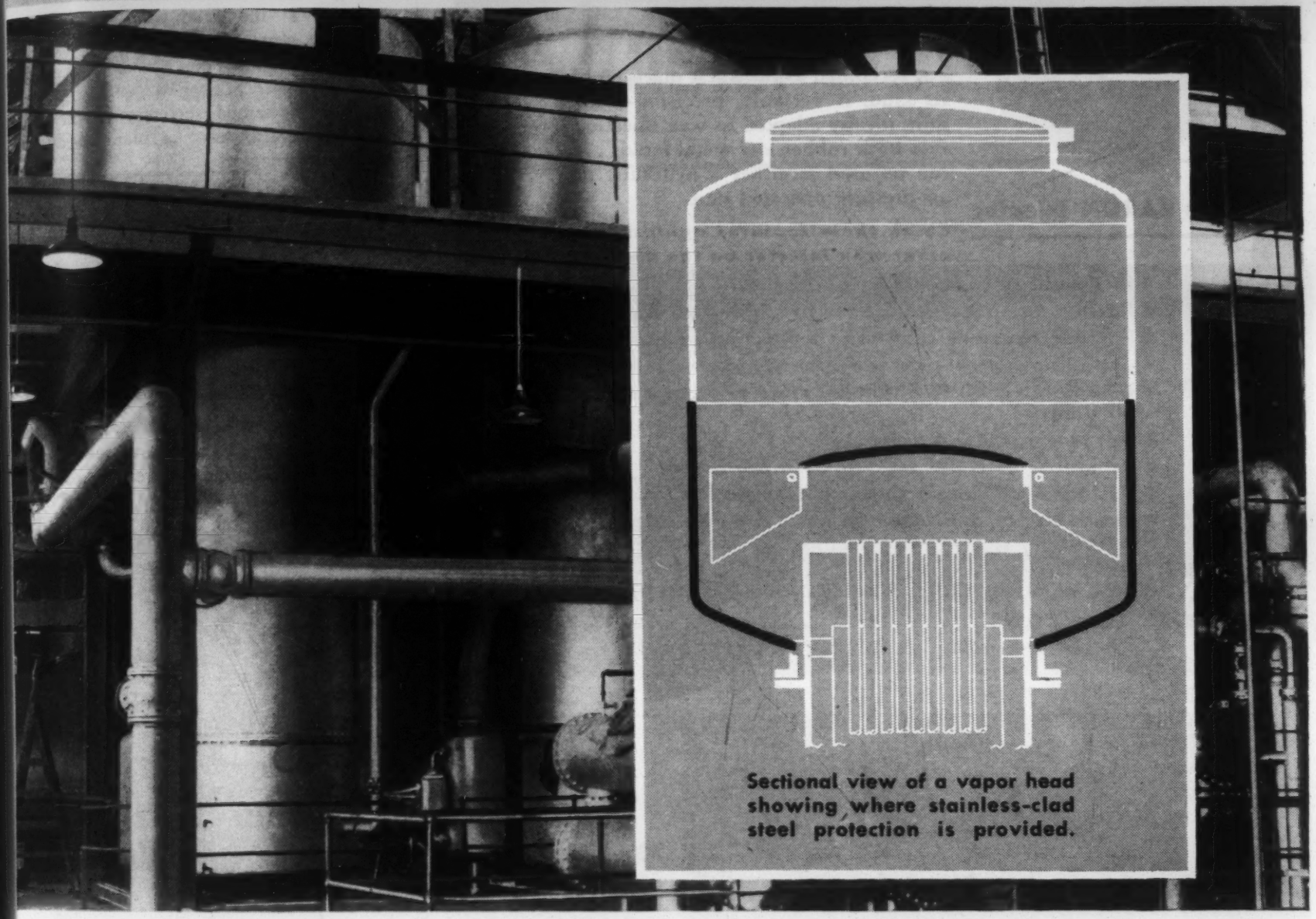
A. W. Pingel has been named industry manager of the new Industrial Parts Div., recently formed by the Reynolds Metal Co. Mr. Pingel, formerly associated with the Revere Copper & Brass, Inc., will have offices located at Plant #14, Louisville, Ky.

The election of *Robert G. Allen* as vice president of the Electrode Div. of the Great Lakes Carbon Corp. occurred recently. Mr. Allen, formerly manager of the Division, will continue to make his headquarters at the Niagara Falls plant.

The Poly-Cyclo Products Co. has appointed *Ray W. Grace* a vice president in

WHEN THE GOING GETS SEVERE,

Swenson Evaporators use Clad Steel



Sectional view of a vapor head showing where stainless-clad steel protection is provided.

Because black liquor gets corrosive as it becomes more concentrated, Lukens Stainless-Clad Steel is used in the first effect and quite often in the second effect.

Ordinary steel faces no corrosion problem in the latter effects of processing in Swenson evaporators. But in the first effect, when the black liquor has become concentrated, corrosive conditions are severe. That's why the vapor head is stainless-clad steel.

Lukens Stainless-Clad Steel provides corrosion protection. A uniform cladding of this corrosion-resistant metal, usually 10% or 20% of the total plate thickness, is permanently bonded to the steel backing plate, offering protection that's equivalent to *solid* stainless steel at the lower cost of *clad* steel.

Other Swenson process equipment uses other Lukens Clad Steels, according to the character of the corrosion they encounter.

Lukens makes Nickel-Clad, Stainless-Clad, Inconel-Clad and Monel-Clad Steels in plates as wide as 178 inches, or to over 3 inches thick—available in the extra smooth, easy-to-clean sodium hydride finish. Bulletins 255 and 338 tell you all about them. For copies, or for help in solving your corrosion problems, write Lukens Steel Company, 419 Lukens Building, Coatesville, Pennsylvania.

CLAD METAL STEEL

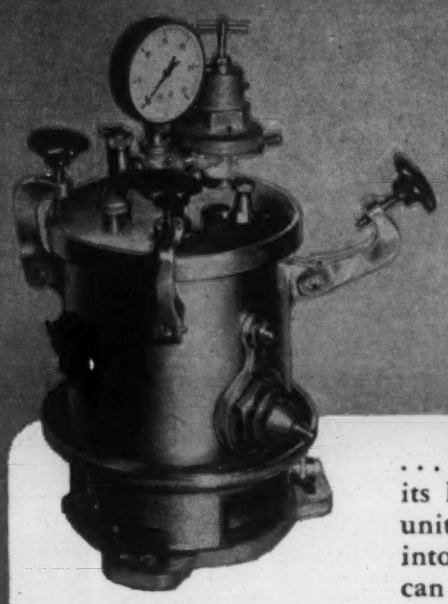
LUKENS

Nickel-Clad Stainless-Clad
Inconel-Clad Monel-Clad
STEELS

Two 16mm Kodachrome motion pictures—"The Manufacture of Lukens Clad Steels" (silent) and "Solving Corrosion Problems" (with sound)—will be loaned to you. Write for booking date.

SOLID METAL ADVANTAGES WITH CLAD STEEL ECONOMY

• • SPEED SCRAP TO THE MILLS TO MAKE MORE STEEL • •



It's Here!

The BARON WAX INJECTOR

. . . acclaimed as the finest machine of its kind. A versatile, precision-made unit, ideally adapted to wax injection into both rubber *and* metal molds . . . can be used as either a hydraulic or air-pressure operated unit.

The BARON Injector

Check these features against any other wax injector on the market:

- **Hydraulic or air-pressure operation**
- **Positive temperature control to within two degrees**
- **Positive pressure control to a fraction of a pound**
- **Complete control over the quantity of wax injected**
- **Complete visibility of temperature and pressure at all times**
- **Full two-quart capacity**
- **Designed for rapid wax pattern production**
- **Designed for simple fool-proof operation**
- **Available for operation on any type of electric current**

Dealers and Jobbers Inquiries Invited

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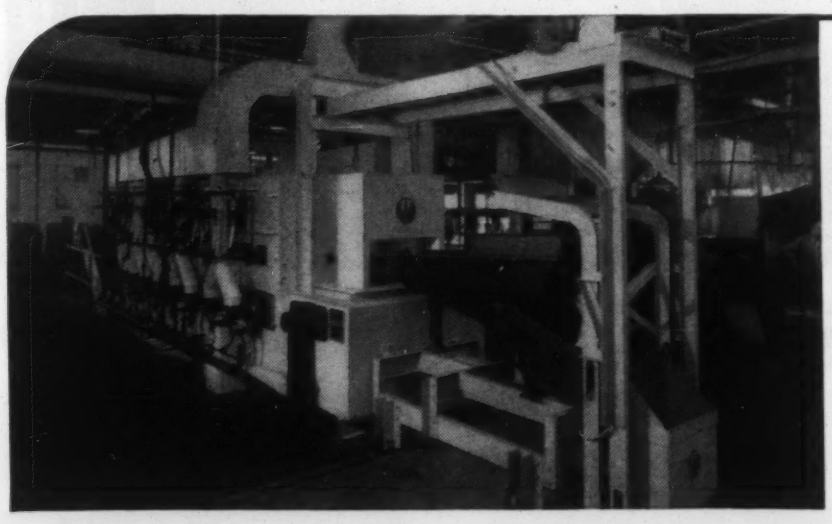
precision casting sales and engineering



EF

GAS-FIRED
OIL-FIRED
and ELECTRIC
FURNACES
for

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ANNEALING
BRAZING
CARBON RESTORATION
CARBURIZING
CERAMIC DECORATING
DRAWING
HARDENING
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MALLEABLIZING
NORMALIZING
NITRIDING
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SPECIAL ATMOSPHERE TREATMENTS

A SIZE AND TYPE OF FURNACE FOR EVERY PROCESS PRODUCT OR PRODUCTION

LOW COST HEAT TREATMENT
of small and medium size parts

• EF chain belt furnaces are the most satisfactory heat treating equipment yet devised for carbon restoration, scale free hardening and hardening without decarburization of small and medium size parts. Built in 11 standard sizes for capacities up to 2,000 lbs. per hour. Larger sizes to meet any requirement. Gas-fired, oil-fired or electrically heated, whichever best suits your particular requirement – and location. Estimates of equipment, installation and operating costs – and samples of treated parts–furnished promptly. Write for literature.

THE ELECTRIC FURNACE CO.
WILSON ST. AT PENNA. R.R. Salem-Ohio

News of...

ENGINEERS
COMPANIES
SOCIETIES

charge of technical sales through the company's industrial affiliate, Munray Products, Inc. Mr. Grace was previously sales manager of the Plastic & Synthetic Div. of the U. S. Stoneware Co. *Ernest A. Munkacsy,* named secretary of the company, will also serve as plant production control manager.

Floyd Rose has retired as chairman of the board of the Firth Sterling Steel & Carbide Corp. He will continue as an active member of the board, however.

The C. M. Kemp Manufacturing Co. has announced the death of *W. Wallace Kemp,* president and chairman of the Board of directors since 1912.

The recent death of *David A. Nemser* was announced by the International Nickel Co., Inc. Mr. Nemser served the company as metallurgist and head of the New England Technical Section of the Development & Research Div.

Companies

The *American Steel & Wire Co.,* Cleveland, Ohio, a subsidiary of the United States Steel Corp., has established a separate stainless steel sales division as part of the company's intensified effort in the field of stainless steel wire, bars and strip. Banks E. Eudy was named manager of the new division, to be known as the Stainless Steel Products Sales Div. Assistant manager will be C. Richard Horwedel.

The first section of the new Research Laboratory of the *General Electric Co.,* being constructed at the Knolls, Niskayuna, N. Y., was formally opened in December. The entire laboratory is expected to be completed in 1950.

The *Penn Rivet & Machine Co.,* Hatboro, Pa., has changed its corporate name to the *Milford Rivet & Machine Co., Penn Div.* James A. Sharkey has been appointed vice president in charge of sales and advertising for this division as well as the company's other two divisions, with offices located in Cleveland, Ohio.

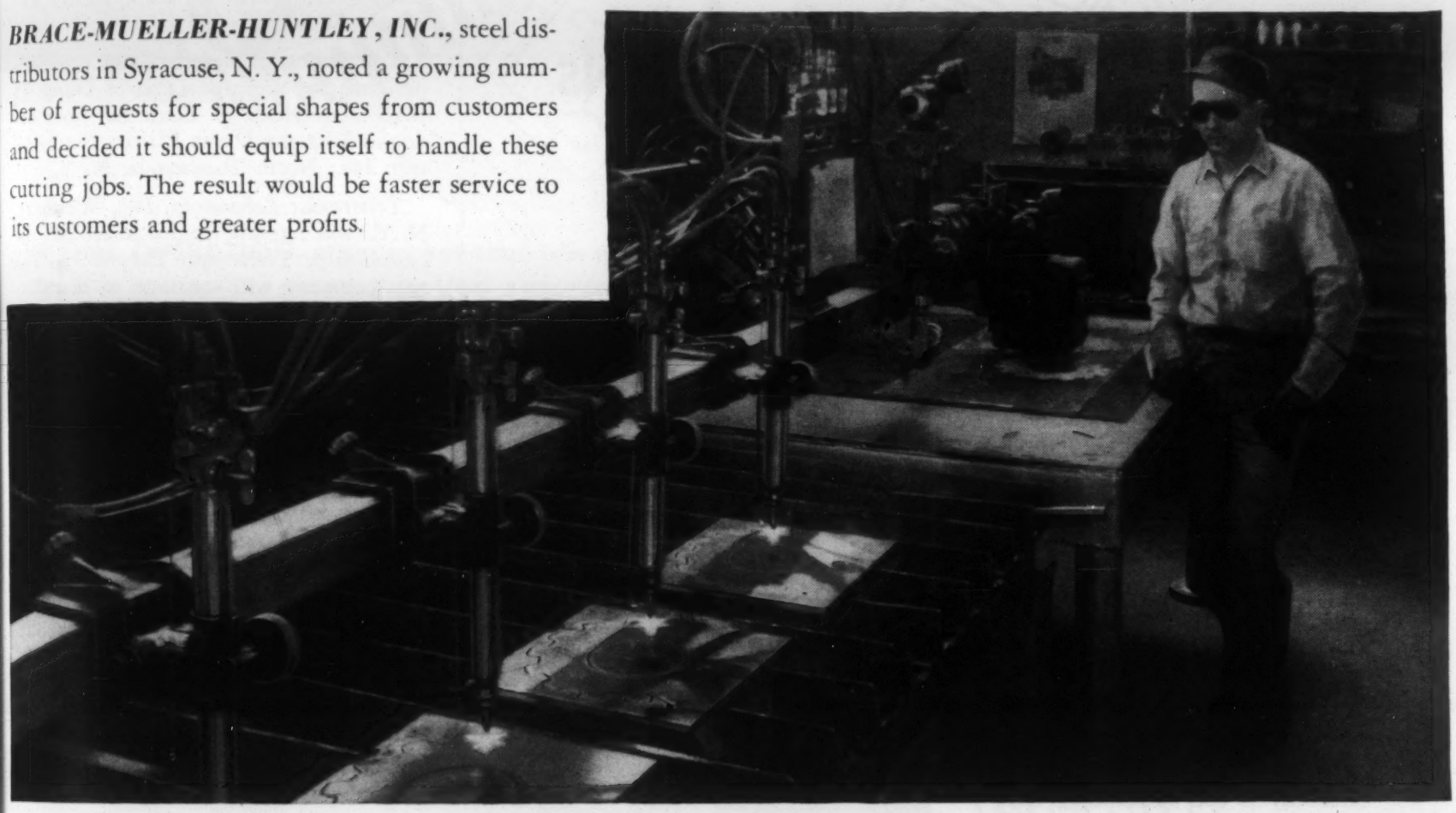
A completely equipped plastics laboratory available to the plastics industry for independent testing and research development has been established in Hoboken, N. J., by the *United States Testing Co.*

Rigidized Metals Corp. is the new name that has been adopted by the former *Rigid-Tex Corp.,* Buffalo, N. Y., to better link the corporate name with its product.

The formation of a Pacific Coast Div. of the *Revere Copper & Brass, Inc.* has

Steel warehouse finds machine gas cutting helps fill special orders... faster—at less cost

BRACE-MUELLER-HUNTLEY, INC., steel distributors in Syracuse, N. Y., noted a growing number of requests for special shapes from customers and decided it should equip itself to handle these cutting jobs. The result would be faster service to its customers and greater profits.



William Burkhardt, Airco Representative, was called in and he recommended machine gas cutting with an Airco No. 6B Oxygraph equipped with a four torch setup and an electronic tracing device.

The apparatus was quickly installed and put into operation. One-day service was offered to customers requiring intricate as well as ordinary shapes.

The executives of Brace-Mueller-Huntley, Inc., stated that the Oxygraph with the electronic tracing device enabled them to make additional profits and also to handle a wide variety of cutting jobs quickly and easily.

TECHNICAL SALES SERVICE — ANOTHER AIRCO PLUS-VALUE FOR CUSTOMERS

To assure its customers of high efficiency in all applications of the oxyacetylene flame or electric arc, Air Reduction has available the broad, practical experience of its nationwide Technical Sales Division personnel. The collective experience and knowledge of these specialists has helped thousands to a more effective use of Airco processes and products. Ask about this Airco "Plus-Value" service today. Write your nearest Airco office. (In Texas: Magnolia Airco Gas Products Company . . . On West Coast: Air Reduction Pacific Company.)

AIRCO **AIR REDUCTION**

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TITANIUM

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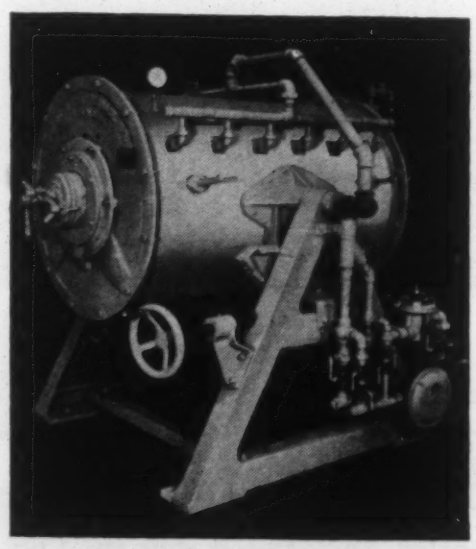
Inquiries Solicited

METAL HYDRIDES INC.

FACTORY AND SALES OFFICES, 12-24 CONGRESS ST., BEVERLY, MASS.

ROTARY GAS CARBURIZERS

A "First" by A.G.F. Co.



Versatility is the outstanding characteristic of AGF Rotary Gas Carburizing Furnaces, which may be used not only for carburizing, but also for clean hardening, normalizing, annealing, and other general or atmospheric work without modification to the furnace of any kind.

Uniform heating of the work is assured by the gentle mixing produced by the rotary action of the retort, which is heated by numerous carefully distributed and balanced gas burners. Carburizing or atmosphere gas is introduced through a simply-designed, trouble-free connection.

Charging and discharging of the work is accomplished by means of a tilting feature, which is power-driven on the larger models. The retort remains within the heat at all times.

The furnace shown above is the latest, improved AGF Rotary Gas Carburizer, batch type, with new maintenance-free roller bearing retort support.

AGF gas carburizing equipment also includes Continuous Rotary Furnaces and Vertical Retort Carburizers. Write for literature.

AMERICAN GAS FURNACE CO.

142 SPRING ST., ELIZABETH, N. J.

News of...

ENGINEERS COMPANIES SOCIETIES

been announced. Copper and copper alloy tube and brass rod will be the principal products fabricated at the new manufacturing plant, located at 6500 E. Slauson Ave., Los Angeles, Calif. Wallace H. Hitchcock was appointed manager of this new division, which includes Revere's district sales offices in San Francisco and Seattle, Wash.

Completion of new facilities especially designed for the production of Durez 75 Black and Durez 77 Black has been announced by the *Durez Plastics & Chemicals, Inc.*, North Tonawanda, N. Y.

Teletronics Laboratory, Inc., Westbury, N. Y., was recently formed to succeed the partnership, *Teletronics Laboratory*. The new company will continue to manufacture the Microdrill and Teletronic Operator, as well as several new products. Robert S. Marston was elected president of the company, and George F. Richards was named vice president and treasurer.

Steel capacity at the *American Steel & Wire Co.'s* Duluth, Minn. Works will be increased 243,000 tons a year as a part of a replacement, improvement and rebuilding program begun by this United States Steel subsidiary.

The *Spencer Thermostat Co.*, a wholly owned subsidiary of the Metals & Controls Corp., has become the *Spencer Thermostat Div.* of the *Metals & Controls Corp.* There will be no change in management or operating policy of the division, located at Attleboro, Mass.

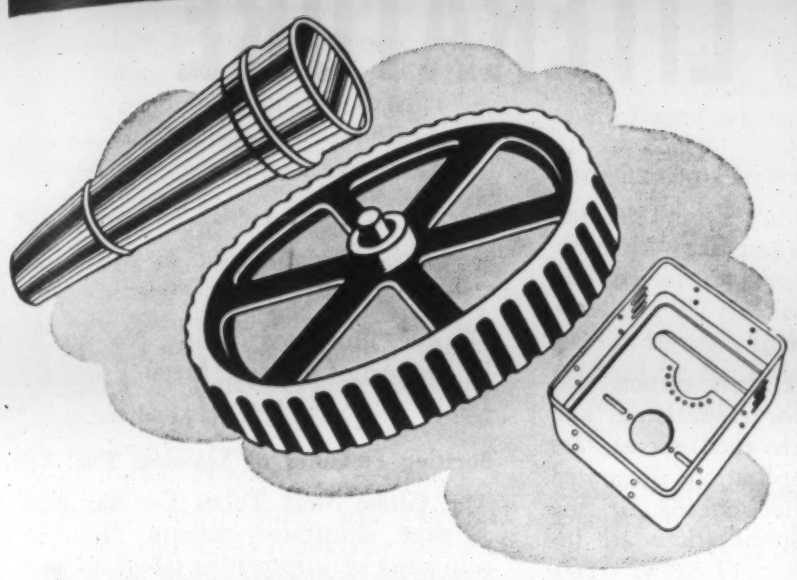
The first experimental coils of hot-rolled steel were successfully manufactured at the *Geneva Steel Co.*, Geneva, Utah, a subsidiary of the United States Steel Corp. The coils will be shipped to the *Columbia Steel Co.'s* cold reduction mill in Pittsburg, Calif., for cold rolling into tin plates and sheets. In addition to the new line of coils, the Geneva plant will continue its regular production of steel plates.

The *Arwood Precision Casting Corp.*, Brooklyn, N. Y., has purchased the precision casting facilities of the *Precise Castings Corp.*, a division of the *Cooper Alloy Foundry Co.*, Hillside, N. J. The acquisition will double the foundry's production capacity for precision casting of steel and will result in a 25% overall increase in total casting potential.

This month marks the 40th year that *Oakite Products, Inc.*, New York 6, has supplied specialized cleaning and allied materials to customers in almost every branch of industry.

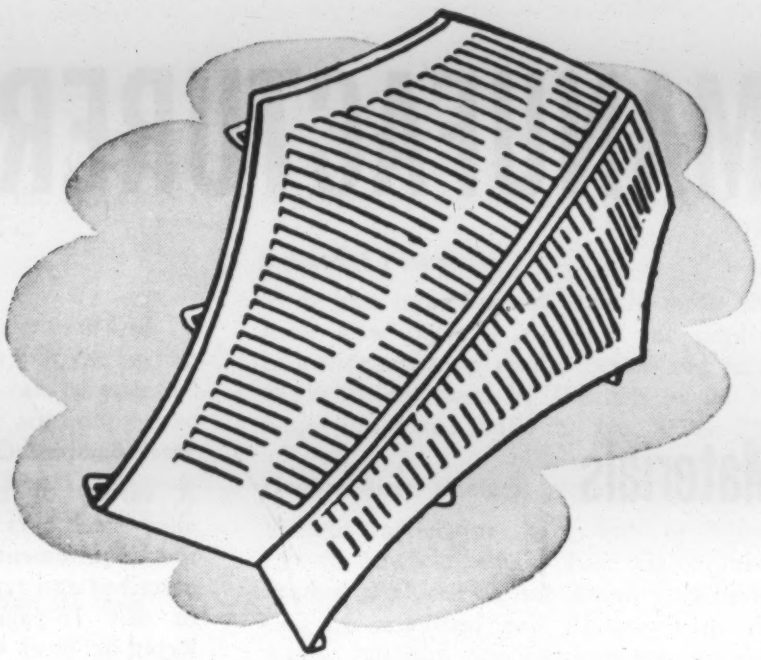
(More News on page 142)

Vapor Degreasing thoroughly removes grease and oil



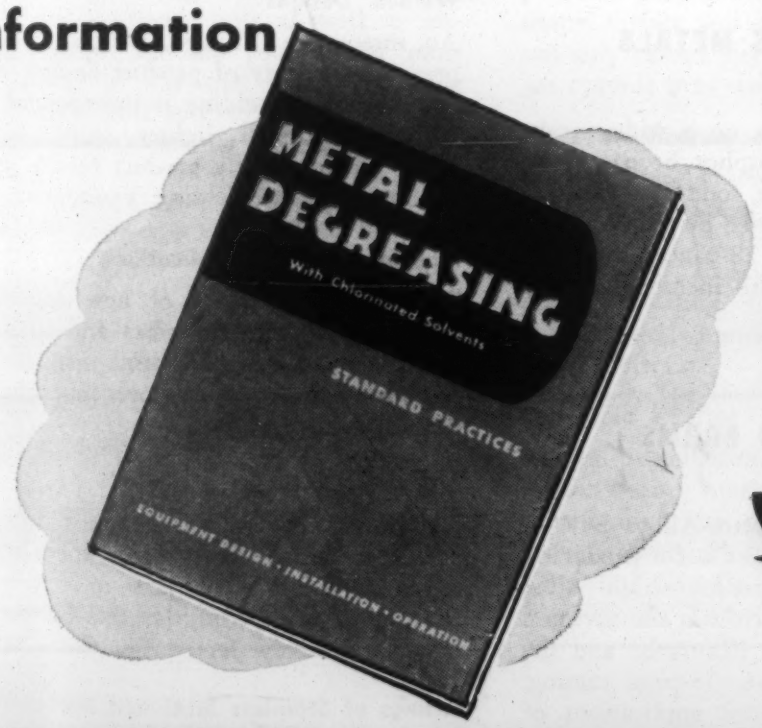
IN ONE OPERATION, often in less than one minute, this economical cleaning method removes all traces of grease and oil from metal parts of any size or shape—plastics, glass and many other materials. It can save time and cut costs in large and small plants because it speeds production and cleaning.

reaches almost inaccessible places . . . reduces risk of damage



VAPOR DEGREASING reaches deep draws, holes and almost inaccessible places. It reduces the risk of damage to small, delicate parts . . . makes possible more accurate inspections during machining operations or assembly. And it renders parts clean, warm and dry—ready for the next operating step.

This book gives full information



"METAL DEGREASING—STANDARD PRACTICES" tells you how to carry out Vapor Degreasing safely and economically. It shows why the results obtained with this method can't be matched. It shows typical compact, scientific equipment, which is available for efficient and economical operation. And it gives information about solvents used in this equipment—Du Pont Trichlorethylene and Perchlorethylene—which under various trade marks have been widely used for many years. Send for it today!

DU PONT non-flammable SOLVENTS for VAPOR DEGREASING

SOLD NATIONALLY THROUGH DISTRIBUTORS

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REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

CLIP THIS COUPON—MAIL TODAY!

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Electrochemicals Dept., Wilmington 98, Delaware

Please send me my copy of "Metal Degreasing—Standard Practices."

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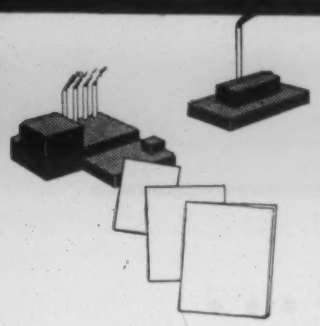

MANUFACTURERS' LITERATURE

Materials

IRON AND STEEL

Stainless Steel Fastenings

List prices per 100 pieces of a complete line of Anti-Corrosive stainless steel set screws, sheet metal screws, washers, and wood screws are featured in this attractive, 80-page, illustrated catalog, No. 48, issued by the Anti-Corrosive Metal Products Co., Inc. (1)

Bursting Pressures of Seamless Steel Tubing

The Globe Steel Tubes Co. has issued a 12-page, illustrated bulletin, No. 112 A, consisting of informative tables on bursting pressures in psi. of seamless steel tubing for each 10,000 psi. of steel tensile strength, based on Barlow's Formula. (2)

Triple Control Method for Heat Treating Steel

The Leeds & Northrup Co. has issued a 32-page, illustrated catalog, No. TB 2-621, describing its Vapocarb-Hump furnaces with the triple-control method which regulates atmosphere, rate of heating and quench point to provide hardened steel of proper shape, surface and structure. These furnaces not only harden steel, but can carburize and gas cyanide it as well. (3)

Meehanite Metal Applications

The third of a series of new application bulletins, No. 30, describes and illustrates the current uses of Meehanite castings. This bulletin, eight pages, has been published by the Meehanite Metal Corp. (4)

Corrosion Guide for Stainless Steel Castings

This 4-page, illustrated bulletin issued by the Alloy Casting Div. of the Michigan Steel Casting Co. contains an informative chart for users of stainless steel castings in selecting the proper Misco alloy to combat various corrosive conditions. (5)

Steel Bars for Carburizing

A variety of Union Drawn carbon and alloy steel bars used for carburizing, and the requirements which each serves, are described and typical applications illustrated in this 16-page booklet offered by the Republic Steel Corp. Specifications are included. (6)

Free-Machining Alloy Steel

Sizes and shapes, hardenability, mechanical properties, analysis and applications of Rycut, a free-machining alloy steel furnished in round, square and flat bar stock, in the hot rolled and annealed condition or heat treated ready to use, are included in this 4-page, illustrated bulletin offered by Joseph T. Ryerson & Son, Inc. (7)

NONFERROUS METALS

Phosphor Bronze Alloys

Complete technical data on a wide variety of Elephant Brand phosphor bronze alloys for strip and sheet, wire, rod, rope, castings, bushings, etc. are presented by the Phosphor Bronze Corp. in its 28-page, illustrated catalog. Specifications are included. (8)

PARTS AND FORMS

High Alloy Castings

The facilities of the Electro-Alloys Div. of the American Brake Shoe Co. for producing Thermalloy and Chemalloy—high alloy castings that are heat, corrosion and abrasion resistant—are profusely illustrated and described in this attractive, 58-page catalog, No. T-155. Recommended applications of these castings in a variety of industries are included. (9)

Stainless Steel Fastenings

List prices per 100 pieces of a complete line of Anti-Corrosive stainless steel set screws, sheet metal screws, washers, and wood screws are featured in this attractive, 80-page, illustrated catalog, No. 48, issued by the Anti-Corrosive Metal Products Co., Inc. (10)

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Centrifugal Die Castings

First detailed information on the Centri-Die process of centrifugal casting in permanent molds is contained in this 12-page, illustrated bulletin, offered by the Lebanon Steel Foundry. A table of general type compositions adaptable to Centri-Die production is included. (12)

Welded Designs

An interesting 16-page, illustrated reprint presents a variety of product designs showing that when welding is incorporated in a design, a stronger, lighter, more pleasing, and often less costly product results. James F. Lincoln Arc Welding Foundation. (13)

Meehanite Metal Applications

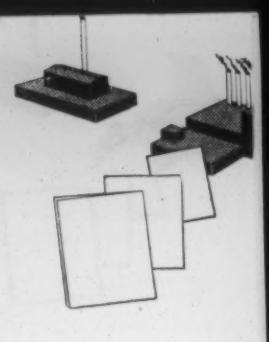
The third of a series of new application bulletins, No. 30, describes and illustrates the current uses of Meehanite castings. This bulletin, eight pages, has been published by the Meehanite Metal Corp. (14)

Zinc Die Castings

Sixty-three pages of photographs depicting the use of zinc die castings in the assembly of 167 different products in ten major consuming fields comprise this booklet offered by the New Jersey Zinc Co. (15)

Fittings of Stainless Steel and Nickel Alloys

Specifications and prices of a wide variety of Nibcoloy wrot fittings available in Inconel, Nickel, Monel, and stainless steel Types 304, 347 and 316—in sizes ranging from ¼- to 4-in. O.D.—are included in this 12-page, illustrated bulletin, No. 902, released by the Northern Indiana Brass Co. (16)



MANUFACTURERS' LITERATURE

Polystyrene Molding Powder

Complete data on Plexene M, a modified polystyrene powder for injection molding, are presented by the Plastics Dept. of the Rohm & Haas Co. A table of properties and typical applications are included in this 12-page, illustrated booklet. (17)

Precision Investment Casting

An introduction to precision investment casting is interestingly presented by Alexander Saunders & Co., in a 12-page, illustrated bulletin, including operating procedure and methods, capital and labor requirements, and expendable supplies. (18)

Custom-Fabricated Rubber Products

A wide range of custom-fabricated rubber products available in such synthetic rubbers as Buna S, Neoprene, Buna N, Thiokol, silicone, and in natural or reclaimed rubbers are discussed in a new catalog just published by the Stalwart Rubber Co. (19)

Brass and Bronze Extrusions

The chemical composition and physical properties of nine alloys commonly used for Titan extruded shapes, available in standard sizes of half rounds and half ovals, are included in this 4-page, illustrated bulletin published by the Titan Metal Manufacturing Co. (20)

NONMETALLICS

Industrial Diamonds and Diamond Tools

This 12-page, illustrated booklet, No. 7, contains helpful suggestions for selecting the proper diamond tools as well as important points for the proper and most efficient use of diamond tools. Available from Anton Smit & Co., Inc., the booklet also gives specifications, prices and applications. (21)

Methods and Equipment

HEAT TREATING

Super Refractories for Heat Treatment Furnaces

A concise description of a variety of super refractories for heat treatment furnaces, their physical characteristics, how they are applied to specific types of furnaces, operational advantages, installation data, and numerous tables comprise this 40-page, illustrated bulletin offered by the Refractories Div. of the Carborundum Co. (22)

Recirculating Furnaces

Outstanding features of many standard recirculating furnaces in batch, pot, car bottom and conveyor types, which can be operated with gas, oil or electricity, are enumerated in this 16-page, illustrated bulletin, No. 81, released by the Despatch Oven Co. Specifications and typical applications are included. (23)

Metal Heating Furnaces, Burners and Equipment

This 4-page bulletin, No. 1100, describes and illustrates a complete line of metal heating furnaces, burners, blowers, controllers, etc., produced by the Johnston Manufacturing Co. The furnaces are either oil or gas fired. (24)

Triple Control Method for Heat Treating Steel

The Leeds & Northrup Co. has issued a 32-page, illustrated catalog, No. TB 2-621, describing its Vapocarb-Hump furnaces with the triple-control method which regulates atmosphere, rate of heating and quench point to provide hardened steel of proper shape, surface and structure. These furnaces not only harden steel, but can carburize and gas cyanide it as well. (25)

Induction Heating

This comprehensive, 48-page, illustrated brochure on Tocco induction heating contains sections on the general principles involved, and actual case histories of induction heating for hardening, forging, brazing and annealing operations. Ohio Crankshaft Co. (26)

Electronic Heating

Typical installations of electronic heating, welding and brazing are illustrated and described in this 4-page bulletin available from Scientific Electric Div., "S" Corrugated Quenched Gap Co. Special equipment built by Scientific Electric is also pictured. (27)

WELDING AND JOINING

Helium Shielded Arc Welding

An interesting, 16-page, illustrated reprint covering complete data on how to use helium shielded arc welding, and including case histories of specific applications of Heliwelding, numerous graphs and charts is offered by the Air Reduction Sales Co. (28)

Industrial Fasteners

Time and money-saving case histories that show how Bostitch machines for stapling and wire stitching render better and faster work are reviewed by Bostitch in its 16-page, illustrated bulletin, No. PTG 223. (29)

Electric Rivet Heaters

Various models of 220-, 440- or 550-v., 25- or 60-cycle, single-phase electric rivet heaters produced by the Frank C. Cheston Co. are described and illustrated in this 4-page bulletin. Specifications are included. (30)

Adhesives

A complete line of nonvulcanizing, air-drying cements, heat and air vulcanizing cements, synthetic bonds, rubber to metal adhesives, and Plastilack adhesives is described in this 6-page, illustrated bulletin, No. 9160, released by the B. F. Goodrich Co. (31)

Welded Designs

An interesting 16-page, illustrated reprint presents a variety of product designs showing that when welding is incorporated in a design, a stronger, lighter, more pleasing, and often less costly product results. James F. Lincoln Arc Welding Foundation. (32)

Cold Repairs on Cracked or Broken Castings

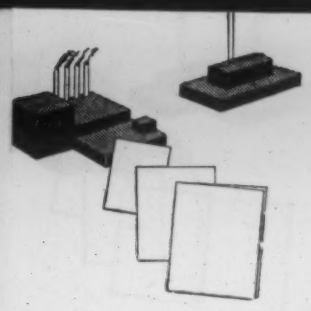
The different techniques used in the Metalock process of making cold repairs on cracked, broken or weakened machine parts or pressure vessels of cast or forged metals are described and illustrated in this 24-page bulletin, No. 104, released by the Metalock Casting Repair Service. (33)

Self-Tapping Screws

Recommended hole sizes in sheet metal, castings, plastics, plywood, forgings and asbestos for a variety of self-tapping screws, plus a chart showing where to use what screw, are featured in this 20-page, illustrated booklet available from the Parker-Kalon Corp. (34)

Cable Connections for Electric Welding

A complete line of Twecotong and Hol-Grip electrode holders, Redhead ground clamps, cable connectors, terminal connectors, cable splicers, etc. is described and illustrated in a new 12-page bulletin, No. 7, just released by the Tweco Products Co. Specifications and prices are included. (35)



MANUFACTURERS' LITERATURE

Gas Welding and Flame Cutting Apparatus

A comprehensive portion of a large line of gas welding and flame cutting apparatus produced by the Victor Equipment Co. is profusely illustrated and described in this 40-page catalog, No. 20B. Specifications are included. (36)

FORGING AND FORMING

Hydraulic Presses

Detailed specifications of a complete line of standard and custom-built steam platen presses for use in the fabricating of belting, gaskets, grinding wheels, plastic laminates, etc. are featured in this 12-page, illustrated bulletin, No. 286, offered by the Baldwin Locomotive Works. (37)

Hydraulic Punching Units

A new line of standardized hydraulic punching units with cylinders interchangeable on different types of bases is described and illustrated in a 4-page bulletin, No. 51-48, issued by the Progressive Welder Co. (38)

MACHINING

Grinders and Surfacers

Specifications and prices of various models of AB wet power grinders, bench grinders, belt surfacers and duo-belt wet surfacers are featured in this 6-page, illustrated folder, offered by Buehler Ltd. (39)

Roll Grinding Machines

A variety of Filmatic 20-, 24- and 28-in. heavy duty traveling table roll grinding machines produced by Cincinnati Grinders, Inc. are profusely illustrated and described in this 12-page bulletin, No. G-587. Detailed specifications are included. (40)

High-Speed Band Saws

A complete size range of 13 high-speed Zephyr band sawing machines for the contour cutting of a great variety of materials is described and illustrated in this 8-page bulletin, offered by the Do All Co. Detailed specifications and typical applications are included. (41)

Insert Chaser Die Heads

Two types of H & G insert chaser die heads for Davenport automatic screw machines are described and illustrated in this 4-page bulletin, No. 15, released by the Eastern Machine Screw Corp. Specifications are included. (42)

Jig Borer

A Type 4C high precision jig borer with automatic features capable of fine adjustment with the highest possible accuracy is described and illustrated in a bulletin available from the Hauser Machine Tool Corp., the U. S. factory representative of Henri Hauser, Ltd. Specifications are included. (43)

Automatic Chucking Machines

Constructional details and specifications of the Models 86 and 88 work rotating 8-spindle automatic chucking machines designed with open-end construction to provide maximum accessibility to all tools are featured in this 8-page, illustrated bulletin issued by the New Britain-Gridley Machine Div. of the New Britain Machine Co. (44)

Abrasive Belt Machine

The new Model WG-4 abrasive belt machine, which combines perfectly flat contact grinding with accurate, speedy platen grinding, is fully described and illustrated by the Porter-Cable Machine Co. in its 6-page brochure. Detailed specifications are included. (45)

Centerless Grinding Wheels

Suggestions for better operating efficiency when using centerless grinding wheels produced by the Simonds Abrasive Co. as well as wheel recommendations for grinding on all types of metal are featured in this 8-page, illustrated bulletin, No. ESA-55. (46)

Precision Lathes

New 13- and 14½-in. swing precision lathes equipped with 1-in. maximum collet capacity headstock spindles, as well as chucks, collets and other accessories for use with these new larger spindles, are described and illustrated in this 4-page bulletin, No. 73, available from the South Bend Lathe Works. Specifications and prices are included. (47)

CLEANING AND FINISHING

Pickling Acid Inhibitor

The many advantages of using Rodine, an acid inhibitor produced by the American Chemical Paint Co., for improving the quality of the pickling, or cleaning, and save acid, metal and money are featured in this 6-page, illustrated folder, No. 700. (48)

Metal Cleaning Equipment

A complete line of Wheelabrator metal cleaning equipment for use in the heat treating and forging industries is fully described and illustrated in an attractive, 20-page bulletin released by the American Wheelabrator & Equipment Corp. Typical applications are also listed. (49)

Emulsion Cleaner

Numerous savings in time and money accrued when Ahcoloid Emulsion Cleaner is used to replace many degreasing solvents are enumerated in this 6-page, pocket-size folder issued by the Apothecaries Hall Co. (50)

Rust Remover

Five outstanding advantages received when using Diversey Everite for safely removing rust, heat scale, hard water scale and discolorations from metal surfaces are listed in this single, illustrated sheet issued by the Diversey Corp. (51)

Buffing with Cloth Wheels

This useful, 8-page, pocket-size booklet contains suggestions on how to choose the correct buffing wheel, type of composition to use, operational performance, and specifications of a variety of prefaced buffing wheels produced by the Divine Brothers Co. (52)

Ventilated Buffs

The many advantageous features of Jackson Airway ventilated buffs, such as faster cutting, cleaner and cooler running, will not ridge work, use less compounds, etc., are listed in this 4-page, illustrated bulletin, offered by the Jackson Buff Corp. (53)

Industrial Finish

Synpex, a finish for metal, wood or plastic products that combines the beauty and durability of synthetic enamels along with the quick drying properties of lacquers, is available clear or as metallic and enamel finishes in most colors, and can be applied by the spray or dip method, is discussed in Bulletin No. 106, offered by the Maas & Waldstein Co. (54)

Blasting Nozzles

A complete series of Super-Titan blasting nozzles with the exclusive Titan tungsten carbide liners and accessories is described and illustrated in a catalog available from Mills Alloys, Inc. (55)

Air Drying and Baking Primer

Two technical data sheets published by the Princeton Paint Laboratories contain recommended uses, outstanding properties, method of application, drying schedule, etc. of its Primer #10, an air drying and baking primer for all metals, which can be applied by spray, dip or brush. (56)

ELECTRUNITE STAINLESS STEEL TUBING IS

Uniform Throughout

● Throughout every length and every shipment you can depend upon consistent uniformity in ELECTRUNITE Stainless Steel Tubing.

As made by Republic's modern processes of cold-forming and electric welding, each length of ELECTRUNITE Tubing is uniform in wall thickness, diameter, concentricity and high ductility. Close visual inspection of the flat-rolled steel before it is formed into tubular shape, gives positive assurance that the inner surface of every tube is free from any trouble-inviting defects.

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HOW THE WROUGHT BRASS INDUSTRY CONSERVES METAL

No industry melting *commensurate tonnage** of vital metal can quite match the brass mills for conservation and low melting losses. The savings of metal total millions of pounds; clearly the method they use is worth noting:

Virtually all the brass mills in North America use the Ajax-Wyatt induction melting furnace, for it has the lowest metal losses in the field — less than 1% — with superior temperature control and unapproached economy of operation on high production schedules such as we have today.

The accepted melting tool in brass rolling mills throughout the world.

* *Upwards of 5 billion pounds annually.*

AJAX ELECTRIC FURNACE CORP.

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ASSOCIATE COMPANIES: AJAX METAL COMPANY, *Non-Ferrous Ingot Metals and Alloys for Foundry Use*
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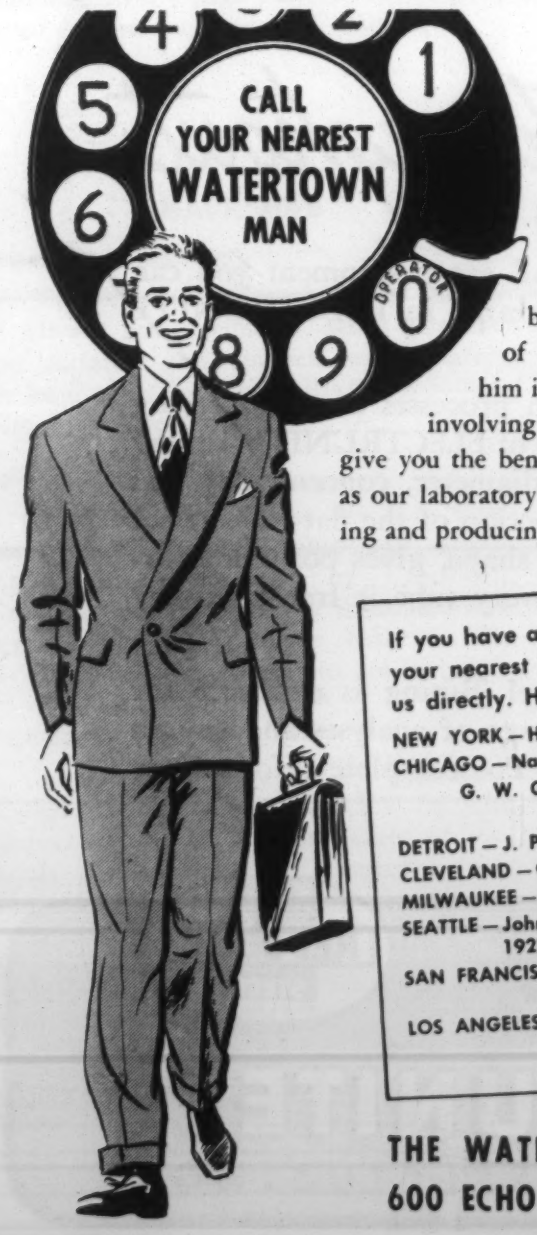

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Your Watertown man is an expert in plastics, backed by 34 years of experience with every type of plastic, every type of molding method. Calling him in to quote or consult on any part, product *or idea* involving molded plastic won't cost you a cent . . . will give you the benefit of our design and engineering skill, as well as our laboratory — second to none in the industry — in developing and producing the job to your satisfaction and your customers'.

If you have a custom molded plastics job on the fire, phone your nearest Watertown man today . . . or phone or write us directly. Here are the Watertown men . . .

NEW YORK — H. A. Rankow, 175 Fifth Ave.
CHICAGO — National Insulations Company, 2808 W. Lake St.
G. W. Glaescher J. P. Greener R. C. Farquhar
J. P. Bonnamy J. R. Kallaher
DETROIT — J. P. Greener from Chicago
CLEVELAND — Carl F. Linn, 866 Hanna Bldg.
MILWAUKEE — Roger L. Miller, 729 N. Broadway
SEATTLE — John W. Witherow, National Vulcanized Fibre Co. 1927 First Ave., South
SAN FRANCISCO — G. W. Harmssen, National Vulcanized Fibre Co. 273 Seventh Ave.
LOS ANGELES — Fred M. Foley, National Vulcanized Fibre Co. 2325 East Eighth St.

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600 ECHO LAKE RD., WATERTOWN, CONN.

News of...

ENGINEERS
COMPANIES
SOCIETIES

Societies

T. W. Atkins, executive vice president of the *Magnesium Association*, has resigned from this post to enter into his own business in the banking field in Painesville, Ohio. No selection has been made as yet of Mr. Atkins' successor.

The *Society of Automotive Engineers* has elected Stanwood W. Sparrow as its president for 1949. Mr. Sparrow is vice president in charge of engineering of the Studebaker Corp.

The Cleveland-Cliffs Iron Co. has established a graduate fellowship in metallurgical engineering at the *Michigan College of Mining & Technology*, Houghton, Mich. Applicants are limited to those students who have received a bachelor of science degree in metallurgical engineering or in mineral dressing from an approved college or university in the United States or Canada.

Newly elected officers of the *American Metallizing Contractors Assn.* consist of the following: president—Peter G. Dennison, president of the Metal Spraying Corp.; vice president—K. B. Smith, vice president and general manager of the Dix Engineering Co., Inc.; and reelected as secretary-treasurer — Walter B. Meyer, manager of the Metallizing Div. of the John Nooter Boiler Works Co. Harry W. Moore, vice president of the Alloy Welding & Manufacturing Co., was elected chairman of the board of directors.

The Hoover Medal for 1948 was awarded to Malcolm Pirnie, consulting engineer and head of the firm of Malcolm Pirnie Engineers, in special recognition of Mr. Pirnie's leadership in the formulation of a program sponsored by the Engineers Joint Council for the postwar industrial control of Germany and Japan. The Hoover Medal is jointly awarded by the *American Society of Civil Engineers*, the *American Society of Mechanical Engineers*, the *American Institute of Electrical Engineers*, and the *American Institute of Mining & Metallurgical Engineers*.

Carl H. Spannaus was elected chairman of the newly organized Denver Management Group of the *Gray Iron Founders' Society*. Mr. Spannaus is associated with the Fountain Iron & Brass Foundry.

The National-Standard Co., Niles, Mich., has established an Industrial Fellowship at the *Mellon Institute* in Pittsburgh to investigate major problems related to the technology of fine wire products and of flat strip. The Fellowship is headed by Charles H. T. Wilson, formerly metallurgist with the Copperweld Steel Co.

DESIGN IDEAS THAT PAY

in MADISON-KIPP *aluminum die castings*

MICRO SWITCH designers, committed by tradition to highest quality material, required a sturdy interchangeable name plates design.

Madison Kipp casts four accurately spaced and accurately sized rivets in a recessed die cast cover to accommodate a variety of name plates.

Engineers and designers often find helpful cooperation by Madison Kipp craftsmen whose life work has been the practical application of die castings to new uses.

Illustrated, the Type "F" MICRO-SWITCH, a product of Micro-Switch, Freeport, Illinois

MADISON-KIPP CORPORATION

218 Waubesa Street, Madison 10, Wis., U.S.A.

ANCIENS ATELIERS GASQUY, 31 Rue du Marias, Brussels, Belgium, sole agents for Belgium, Holland, France, and Switzerland.

WM. COULTHARD & CO. Ltd., Carlisle, England, sole agents for England, most European countries, India, Australia, and New Zealand

- *Skilled in* DIE CASTING *Mechanics*
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Improve Surface Finishes Increase Tool and Die Life

with PANGBORN HYDRO-FINISH

What is Pangborn Hydro-Finish? It's the new, versatile impact blasting process that uses a fine mesh abrasive suspended in water, yet holds tolerances of the work to .0001 inches.

What Hydro-Finish can do for you Pangborn Hydro-Finish can help you three ways, by improving surface finishes, by removing oxide scale, by lengthening tool and die life through proper maintenance. Here's how . . .

In the Production Line . . . It eliminates many tedious finishing operations. It reduces cost and time involved in buffing. It improves fatigue life of the metal parts it finishes. It cuts many varied manufacturing costs.

In the Tool Room . . . New Hydro-Finish simplifies the manufacture and maintenance of tools, dies and molds. It reduces usual costly handwork and produces a surface virtually free from directional grinding lines.

Write today for details about the new Pangborn Hydro-Finish Cabinet. PANGBORN CORPORATION, 1203 Pangborn Blvd., Hagerstown, Md.

Look to Pangborn For All Latest Developments In Blast Cleaning And Dust Control Equipment.

Pangborn

BLAST CLEANS CHEAPER
with the right equipment for every job

Meetings and Expositions

AMERICAN SOCIETY FOR TESTING MATERIALS, Committee week and spring meeting. Chicago, Ill. Feb. 28-Mar. 4, 1949.

INSTITUTE OF RADIO ENGINEERS, national convention. New York, N. Y. Mar. 7-10, 1949.

SOCIETY OF AUTOMOTIVE ENGINEERS, passenger car meeting. Detroit, Mich. Mar. 8-11, 1949.

AMERICAN SOCIETY OF TOOL ENGINEERS, annual meeting. Pittsburgh, Pa. Mar. 10-12, 1949.

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION, winter convention. Chicago, Ill. Mar. 13-18, 1949.

CHICAGO TECHNICAL SOCIETIES COUNCIL, annual conference and production show. Chicago, Ill. Mar. 14-17, 1949.

AMERICAN CHEMICAL SOCIETY, national meeting. San Francisco, Calif. Mar. 27-Apr. 1, 1949.

SOCIETY OF AUTOMOTIVE ENGINEERS, transportation meeting. Cleveland, Ohio. Mar. 28-30, 1949.

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION, Industrial & Commercial Lighting Equipment Section. Chicago, Ill. Mar. 29-Apr. 1, 1949.

SAFETY CONVENTION AND EXPOSITION, annual meeting. New York, N. Y. Mar. 29-Apr. 1, 1949.

METAL POWDER ASSOCIATION, annual meeting and exhibit. Chicago, Ill. Apr. 5-6, 1949.

SOCIETY OF AUTOMOTIVE ENGINEERS, aeronautic and air transport meeting. New York, N. Y. Apr. 11-13, 1949.

NATIONAL ASSOCIATION OF CORROSION ENGINEERS, annual conference and exhibition. Cincinnati, Ohio. Apr. 11-14, 1949.

AMERICAN SOCIETY FOR METALS, Western metal congress and exposition. Los Angeles, Calif. Apr. 11-15, 1949.

MAGNESIUM ASSOCIATION, annual meeting. Chicago, Ill. Apr. 14-15, 1949.

MIDWEST POWER CONFERENCE. Chicago, Ill. Apr. 18-20, 1949.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, National Open Hearth Steel Committee annual meeting. Chicago, Ill. Apr. 18-20, 1949.

INTERNATIONAL ACETYLENE ASSOCIATION, annual convention. Pittsburgh, Pa. Apr. 25-26, 1949.

SOUTHERN MACHINERY & METALS EXPOSITION. Atlanta, Ga. Apr. 25-28, 1949.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Oil & Gas Power Div. conference. Chicago, Ill. Apr. 25-29, 1949.

"LET'S LOOK FOR TROUBLE"

Says **CHIP WRIGHT**

"Looking for trouble is a necessary part of efficient operation, because the most efficient shop is one in which troubles are reduced to a minimum.

"A plant honing cylinder blocks was considered to be trouble-free when it was averaging 9.6 blocks per stone and getting a fair finish. However, when a change of honing oil made it possible to hone 15.4 blocks per stone and get a better finish, it was realized that there actually had been *trouble* before this profitable change was made.*

"That's what I mean when I say, 'Let's look for trouble.' Another way of stating it is: 'Where can we find opportunity for improvement?' Frequently the biggest single opportunity lies in the choice of cutting fluids."

—Chip

*The change that improved the honing operation cited above was a mixture of ThredKut 99 recommended by a D. A. Stuart Oil Co. representative. ThredKut 99 is easily mixed or blended whenever a special operation calls for its unusual qualities. Ask for a booklet on D. A. Stuart's ThredKut 99 and other time-tested cutting fluids.

STUART oil engineering goes with every barrel

D. A. Stuart Oil Co.

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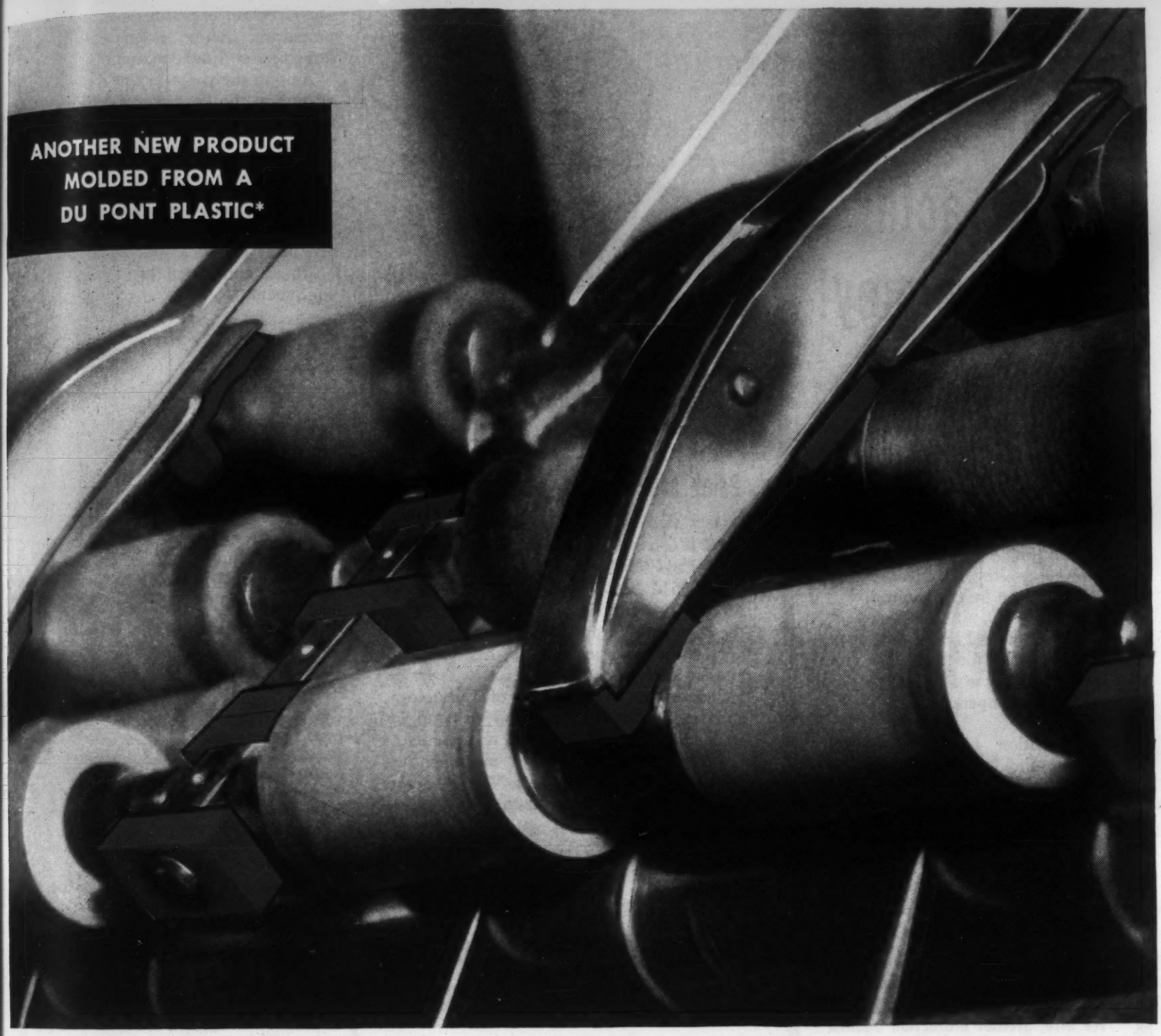


NEW NYLON BEARINGS NEED NO LUBRICATION

Textile-machine parts of Du Pont nylon plastic last for years . . . slash costs

Oil has long been a problem in the making of yarn. In spinning, the yarn is drawn through rollers that stretch and align the fibers. The parts that keep these rollers weighted and in place are called "saddles" and "cap bars." The bearing surfaces of the saddles and cap bars require frequent time-consuming oilings. An average mill may have as many as *135,000 such places to oil* as often as once a day. Frequently, oil gets on the rollers and is transferred to the yarn—necessitating costly cleaning. In addition, the oily rollers pick up lint that must be removed by hand. And when the oil supply on the bearings gets low, the rollers slow down and cause uneven spinning.

But today, yarn makers can solve this problem. For when molded *nylon* bearings replace metal bearings, no lubrication is necessary. They can be installed and practically forgotten. In one textile plant, nylon bearings have been in constant use, without oiling, on all three shifts *for two years . . . and still show little or no wear.*

Big savings result here because use of nylon bearings 1) eliminates oiling, 2) reduces yarn damage, 3) helps maintain uniform yarn quality, 4) virtually ends roll-picking, 5) reduces average power consumption.

This success story is typical of those you'll hear about products molded of nylon. Can nylon plastic solve a problem for you? Write today for helpful facts about this and other versatile Du Pont plastics. Just address E. I. du Pont de Nemours & Co. (Inc.), Plastics Dept., Room 412, Arlington, N. J.

**Saddles and cap bars manufactured by Dixon Lubricating Saddle Co., Bristol, R. I., under the trademark "Slixonice," are equipped with nylon bearings molded by Atlantic Plastics, Inc., Flushing, L.I., N.Y.*

Tune in—Du Pont's famous "Cavalcade of America"—Monday night, NBC coast to coast!

DU PONT
REG U.S PAT. OFF.
Plastics
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

Save steel!
Save acid!
Save money!

USE Oakite Pickle Control No. 3 to inhibit hot sulphuric-acid pickling baths! Use Oakite Pickle Control No. 4 to inhibit hydrochloric-acid pickling baths!

Oakite Pickle Controls minimize attack on steel without retarding action on scale or rust. They prevent waste of acid after scale or rust have been dissolved.

Steel is money! Acid is money! Oakite Pickle Controls save some customers up to 19 cents per ton on pickling operations!

In addition to these savings, Oakite Pickle Controls offer the following advantages:

1. **Reduction of acid fuming—greater safety and comfort for workers.**
2. **Prevention of over-pickling and pitting — brighter surfaces, smoother bases for coats of tin or zinc.**
3. **Reduction of hydrogen embrittlement — shorter baking time for wire, greater protection against blistering of electroplated parts.**
4. **Cleaner work — better rinsing with less smut adhering to surfaces.**
5. **Retardation of iron-sulphate formation—longer life for pickling solutions, less spent liquor.**

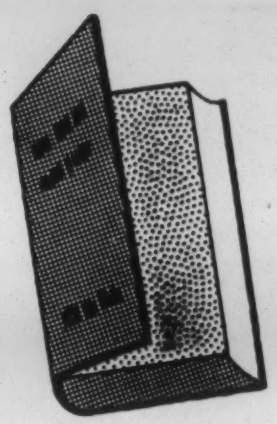
Free Demonstration—The Oakite Technical Service Representative in your vicinity will gladly demonstrate the efficiency of Oakite Pickle Controls. Also write for new Oakite Special Service Report on "Improved Pickling and Neutralizing". Oakite Products, Inc., 32H Thames St., New York 6, N. Y.

OAKITE

OAKITE 1909 1949 40th ANNIVERSARY YEAR

SPECIALIZED INDUSTRIAL CLEANING
MATERIALS • METHODS • SERVICE

Technical Service Representatives Located in Principal Cities of United States and Canada



BOOK REVIEWS

Paint and Varnish Technology

PAINT AND VARNISH TECHNOLOGY. *Edited by William von Fischer. Published by Reinhold Publishing Corp., New York, 1948. Cloth, 6¼ x 9¼ in., 509 pages. Price $8.00.* This volume presents a survey of the chemistry, formulation, manufacture and applications of paints, varnishes, lacquers, and enamels. It originated as a series of lectures at the Case Institute of Technology, and is of value to those who want an introduction to the entire field, to students of protective coatings, and to manufacturers and users of these coatings. The emphasis is on technological aspects, and many data are given on exposure tests, viscosity, film properties, hiding power, special applications and surface preparations.

Among the chapters are those on: Introduction to the Protective Coatings Industry; Drying Oils; Pigments; Rosin and Rosin Derivatives; Natural Resins and Kindred Products; Testing of Raw Materials; Principles of Paint Formulation; Resin and Varnish Manufacture; Industrial Finishes; Water and Emulsion Paints; Solvent-type Finishes; Methods of Applying Surface Coatings; and Resin and Varnish Making Equipment.

Other New Books

DRILLING AND SURFACING PRACTICE—THIRD EDITION. *By F. H. Colvin & F. A. Stanley. Published by McGraw-Hill Book Co., Inc., 1948. Cloth, 6¼ x 9¼ in., 523 pages. Price $5.00.* The most advanced methods in drilling and surfacing operations are described.

PREVENTION OF IRON AND STEEL CORROSION. *By C. Dinsdale. Published by Louis Cassier Co., Ltd., London, S.E. 1, England, 1948. Cloth, 5¾ x 8¾ in., 67 pages. Price 5s. 3d.* An index of the processes and standard specifications relating to the prevention of the corrosion of iron and steel.

SCIENCE AT WAR. *By J. G. Crowther & R. Whidington. Published by Philosophical Library, Inc., New York, 1948. Cloth, 5¾ x 8¾ in., 185 pages. Price $6.00.* An account of science's contribution to the war effort, based on official archives of the Scientific Advisory Committee to the British Cabinet. Deals with radar, the atomic bomb, operational research, and science and the sea.

Makes the Toughest Forging Specifications Seem Easy...

AND BOOSTS PRODUCTION

40%

Every hour this induction heating unit automatically feeds 600 hot connecting rod billets into the tongs of the operator. By virtue of its speed, its split-second control over time and temperature, and its scale-free heating, it gives 40% greater over-all production than the best of other furnace-press combinations considered—four times the rate possible with slot furnace and drop hammer. It's flexible, too. Several units in this plant handle a wide variety of parts with quick changeovers. Yes, in case after case—even on picks and sledges—existing presses are boosted to unheard-of production rates with induction heat—and at lower costs!

Ask for the scores of ideas in Induction Heating Bulletin 13-A

SINCE 1916

AJAX ELECTROTHERMIC CORPORATION
AJAX PARK, TRENTON 5, N. J.
Associate Companies
THE AJAX METAL COMPANY • AJAX ELECTRIC FURNACE CORPORATION
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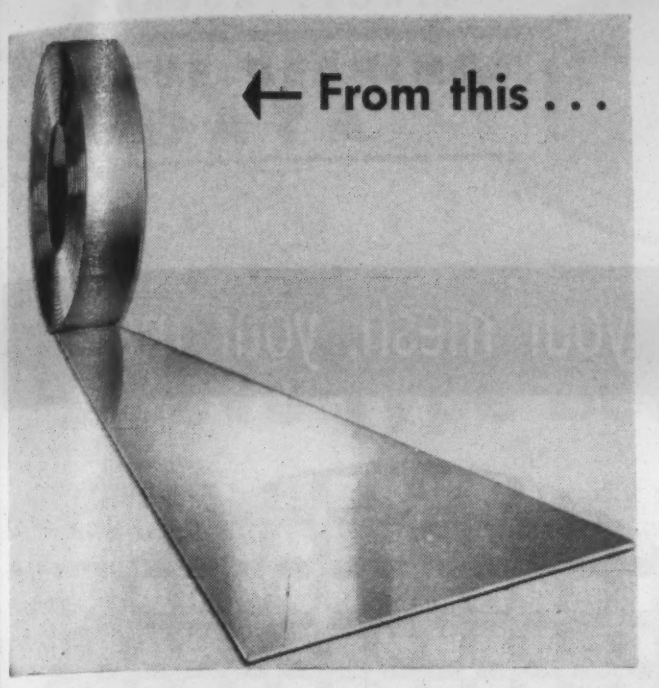


Hunter Manufacturing Corporation roll forms sections of window frame . . . uses Kaiser Aluminum for the job because of its consistent high quality and workability.

Mass produced from coiled sheet in *ONE CONTINUOUS OPERATION!*

HOW? Hunter Manufacturing Corporation, Bristol, Pennsylvania, *roll forms* this section of window frame from a Kaiser Aluminum alloy!

It's a typical example of low cost fabrication possible with the uniform high quality and workability of Kaiser Aluminum.

In this operation Kaiser Aluminum coiled sheet is run through a 20-stand roll forming mill. Despite the severe forming done by these 20 rolls in a progressive operation, the completed section is produced in straight lengths, free from cracks and other defects.

As the continuous formed piece emerges *—at the rate of 75 feet per minute—* a traveling shear cuts it to exact length for final assembly.

What does this mean to you?

In the manufacture of your product, perhaps some parts can be mass produced by roll forming with the proper alloy of Kaiser Aluminum. If so, chances are you can get these tangible, dollars-and-cents benefits: Lower unit cost—greater uniformity of finished parts—improved surface finish—simplified production scheduling and planning.

And—due to Kaiser Aluminum's *lightness*—you'll get lower handling and shipping costs, reduced worker fatigue, lower labor costs!

But most important, you'll get a better product with Kaiser Aluminum! A product that's strong and durable, that won't rust and that can't be matched for sales appeal.

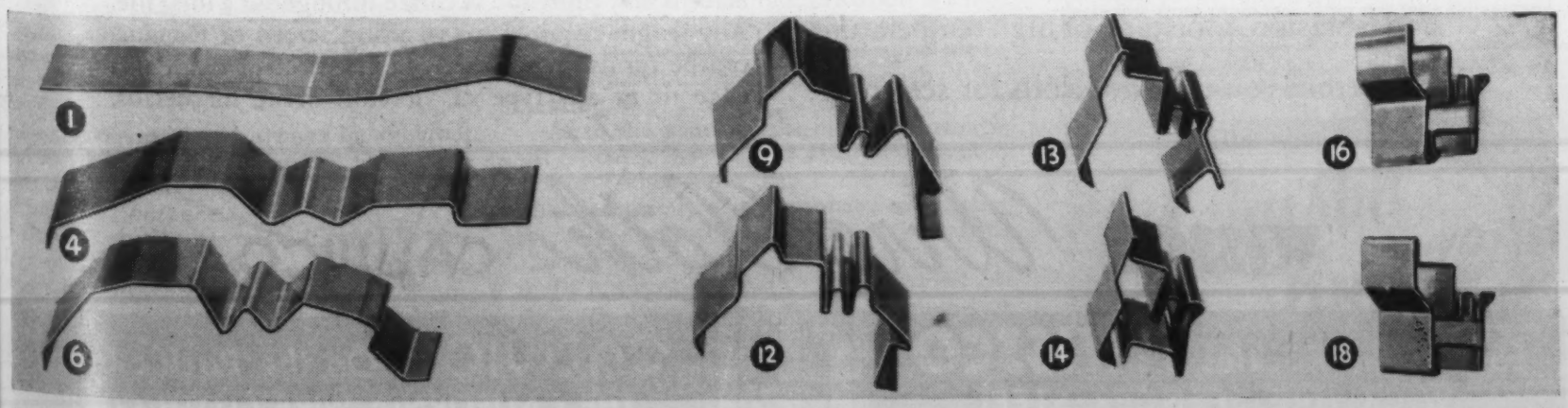
Whether your product is roll formed, spun, drawn, or fabricated by any other method, couldn't *you* lower costs by using the proper alloy of strong, versatile Kaiser Aluminum? Call in a Permanente engineer. He'll help you find the answer!

Permanente Metals

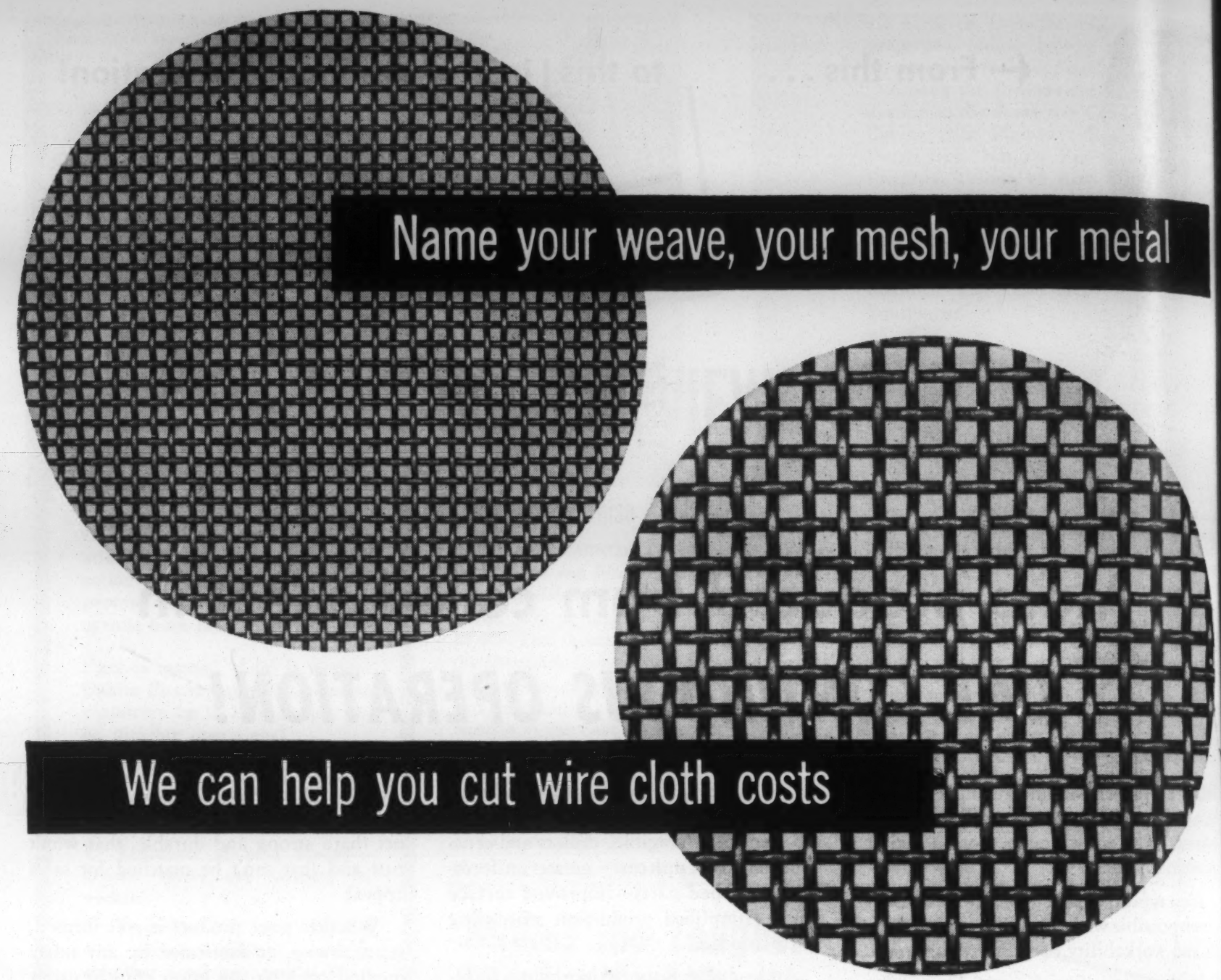
PRODUCERS OF

Kaiser Aluminum

SOLD BY PERMANENTE PRODUCTS COMPANY, KAISER BLDG., OAKLAND 12, CALIFORNIA: OFFICES IN MAJOR CITIES



These cross sections, taken from nine of the 20 stands of a roll forming mill, illustrate progressive stages of fabrication from Kaiser Aluminum coiled sheet to finished section. In one continuous operation an important part of a window frame is rapidly formed!



With manufacturing facilities on both the East and West Coasts, and engineering sales service in key cities throughout the nation, we can help you find the answers to your wire cloth problems.

Backed by 90 years' experience, our service to over 100 industries covers the precision fabrication of wire cloth in a dozen different coarse and fine weaves; in all commonly used metals; to withstand chemical action, corrosion, abrasion, moisture, or high temperature.

Whether you use wire cloth for screening, filtering, grading, cleaning, or processing, you'll find Wissco and Calwico Wire Cloth will give long, dependable service.

Super-Tempered PRECISION SCREENS

Even under excessive vibration these screens won't wear loose in service. They're made of tough super-tempered steel and woven on new modern power looms. Wissco and Calwico Super-Tempered Precision Screens stay tight and accurate throughout a long life. Any length required for vibrating screen or trommel can be furnished with welded, hooked, or reinforced edge to fit any type of vibrator. Write for details.

WISSCO *Wire Cloth* **CALWICO**

East of the Rockies it's **WISSCO**
WICKWIRE SPENCER STEEL
STERLING ST., CLINTON, MASS.

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CALWICO *On the Pacific Coast*
THE CALIFORNIA WIRE CLOTH CORP.
1080—19TH AVE., OAKLAND, CAL.

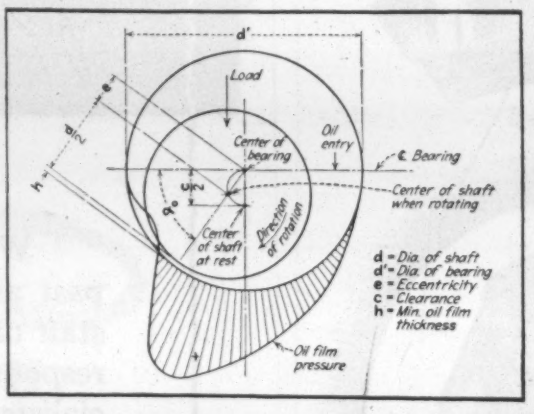
The Lubrication of Sleeve Type Bearings-I

EFFICIENT bearing performance is governed to a great extent by the selection of the bearing material, the bearing design and the method of lubrication. By determining these factors, in relation to the operating conditions, we have the basis for the selection of the proper bearing to deliver the desired performance.

In consideration of the lubrication factor, we must determine the following points: Speed, load, viscosity of lubricant, bearing material, clearance, bearing design, nature of the rubbing surfaces, operating temperature and method of feeding and distribution of lubricant.

While the primary purpose of lubrication is to eliminate mechanical friction and to prevent wear and corrosion, no appreciable amount of power can be transmitted on the best of bearing materials without definite lubrication. Heat develops rapidly when the shaft operates in direct contact with the bearing. Heat is also developed beyond the normal radiating capacity if the viscosity of the lubricant is too high in relation to the speed of the shaft.

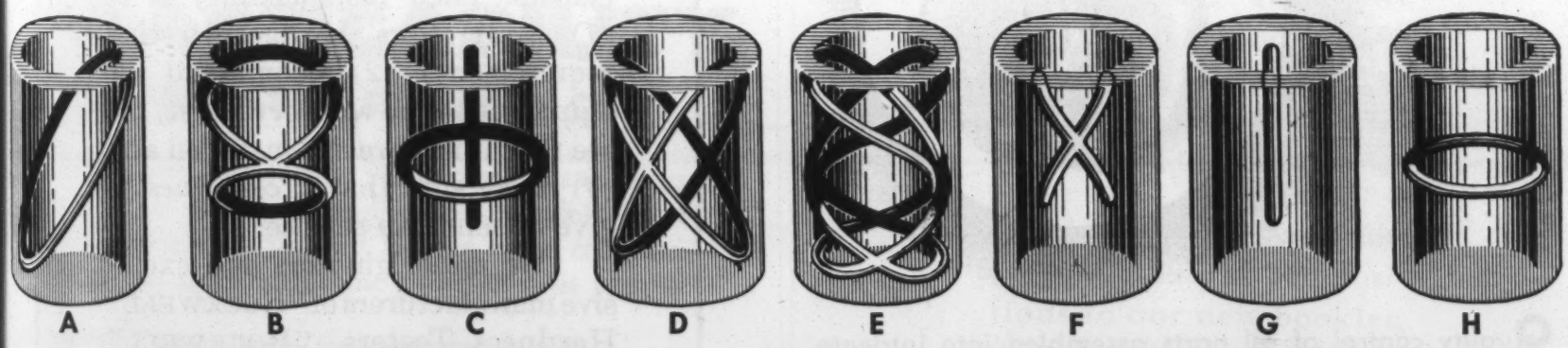
It is a mistaken idea that any type of oil or grease will provide suitable lubrication. The extensive research accomplished by the producers of lubricating materials enables any user of bearings to select the exact type required for his applications. In certain applications it is necessary to provide protection to the lubrication by the use of seals or the design of the bearing. This prevents the lubricant from seeping out with consequent loss and damage to material in process.



With the starting of the shaft the frictional resistance is high. As the speed increases, the lubricant under the influence of the moving part, plus its adhesive qualities, builds up a relatively thick film between the surfaces at the point of nearest approach. The shaft then undergoes a displacement in a direction at right angles to the line of load. The continued speed of the shaft creates a film pressure which increases until an equilibrium is established.

* * *

THE CURVE, as shown at left, represents the distribution of the calculated values of pressure in relation to the bearing reaction. The load-carrying capacity is governed by the maximum pressure that can be developed under the existing conditions. If the load pressure is down—as illustrated—then the curve indicates that the lowest pressure is practically opposite. Obviously this is the proper place for the intake of the lubricant.



Oil Grooving

● The purpose of oil grooves is to assure proper distribution of the lubricant along the length of the bearing in the region just ahead of the loaded area (see above). Complicated and elaborate grooves are in most bearings neither necessary nor useful; they render manufacturing more difficult, and, if not properly placed and executed, may do more harm than good because they may assist in interrupting the oil film.

Deep grooves should always be avoided and both edges of any oil groove should be rounded off to permit free entrance of the oil into the clearance.

Grooves should never be located in the high-pressure area of an oil lubricated sleeve bearing.

In order to obtain quick and uniform distribution of the oil along the length of the bearing, the oil groove should extend axially from the point of entrance and should stop short of the ends of the bearing to minimize oil leakage.

In applications where the direction of rotation changes, spiral oil grooves approaching the high-pressure area, like those shown in (a) and (b), might be expedient.

In many types of split-half bearing, especially when pressure lubrication is used, longitudinal chamfers (relieves) on each side of the bearing halves, are sufficient to secure distribution along the length of the bearing.

As to the points of the oil entry into the oil grooves, they should always be located ahead (relative to the direction of the shaft rotation) of the pressure area; that is, in the unloaded side in bearings with constant load direction.

In applications with changing load direction, the oil entry should be placed at points of minimum oil pressure.

For very long bearings, two oil entrances might be expedient or necessary; if so, they should be connected by one axial distributing groove.

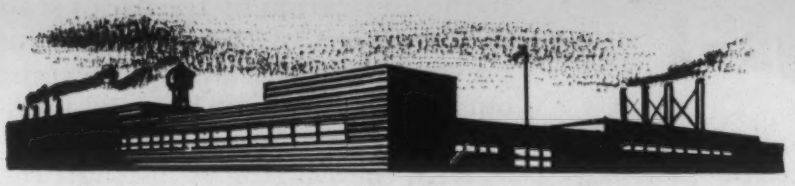
Engineering Service

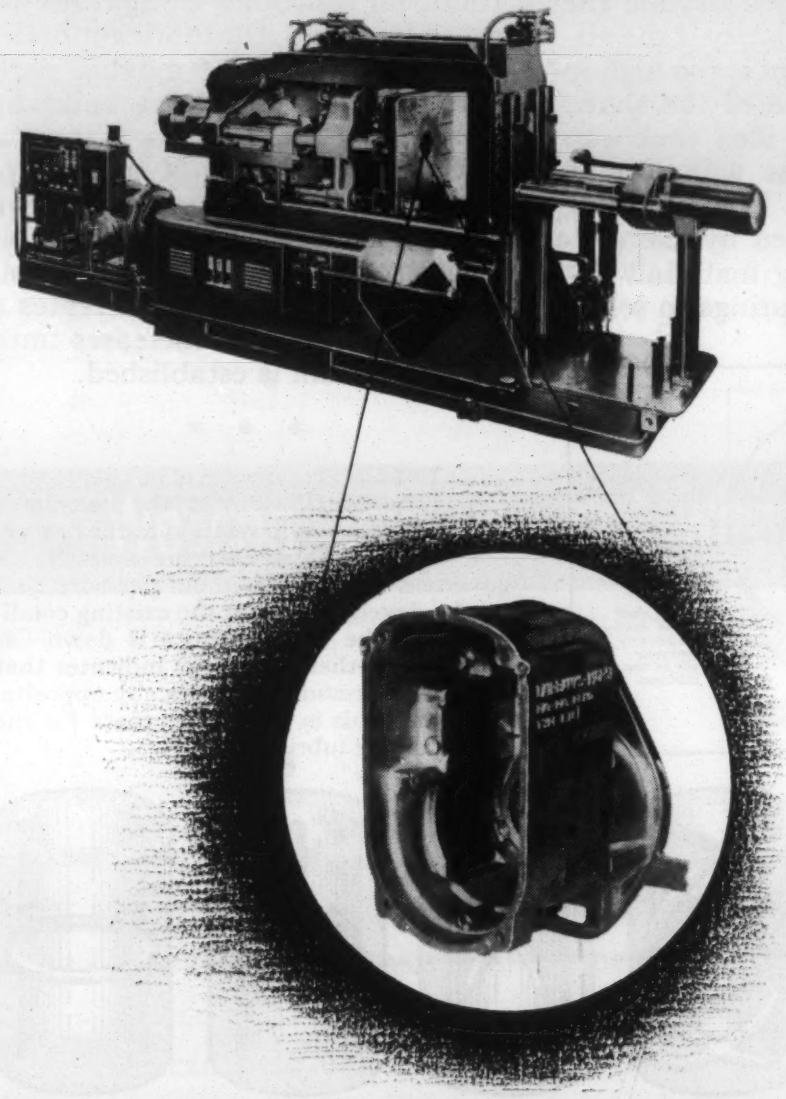
Johnson Bronze offers manufacturers of all types of equipment a complete engineering and metallurgical service. We can help you determine the exact type of bearing that will give you the greatest amount of service for the longest period of time. We can show you how to design your bearings so that they can be produced in the most economical manner. As we manufacture all types of Sleeve Bearings, we base all of our recommendations on facts free from prejudice. Why not take full advantage of this free service?

This bearing data sheet is but one of a series. You can get the complete set by writing to—

Johnson Bronze
SLEEVE BEARING HEADQUARTERS
769 S. MILL ST. • NEW CASTLE, PENNA.

FAIRBANKS-MORSE CONTROLS QUALITY IN THE PLANT WITH LESTER-PHOENIX



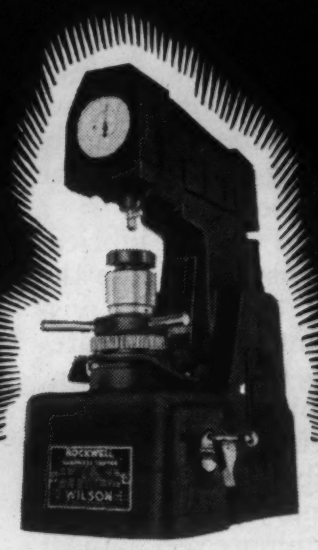


Quality control of all parts assembled into intricate working mechanisms is a must at Fairbanks-Morse in Beloit, Wisconsin. There, plant experts have found that the best means of such control is by die casting parts on Lester-Phoenix equipment in their own plant. Uniform parts and steady, centralized production from Lester-Phoenix die casting machines insures a minimum of assembly problems—and results in maximum efficiency. Your die casting quality and supply problems can be solved by installing Lester-Phoenix equipment in your own plant.

LESTER-PHOENIX
DIE CASTING MACHINES

LESTER-PHOENIX, INC.
2653 Church Avenue • Cleveland 13, Ohio

THE *Helping Hand* IN Precision Hardness Testing



WILSON has maintained in the past and continues to maintain a staff of Field Service Engineers—responsible hardness testing specialists. Their responsibility is to (*1*) study users' hardness testing requirements, (*2*) recommend the equipment that will serve best, (*3*) see that it is correctly installed and (*4*) make sure that it *continues* to give dependable service.

We are originators and exclusive manufacturers of "ROCKWELL" Hardness Testers, "ROCKWELL" Superficial and TUKON Microhardness Testers. Our years of concentration on developing and improving hardness testing equipment give our factory-trained representatives the necessary background for the best possible service to you.

BRALE is the only diamond indenter made to Wilson's precision standards for use on "ROCKWELL" Hardness Testers and "ROCKWELL" Superficial Hardness Testers.

WILSON
MECHANICAL INSTRUMENT CO., INC.
AN ASSOCIATE COMPANY OF AMERICAN CHAIN & CABLE COMPANY, INC.
230-E PARK AVENUE, NEW YORK 17, N. Y.

THE SPERRY REFLECTOSCOPE

For Rapid, Accurate Non-Destructive Testing

of METALS AND OTHER MATERIALS

MAXIMUM IN PRACTICABILITY

AT GREATLY REDUCED COST

The Sperry Type SRO5 Reflectoscope can be used in all the variety of applications possible for the previous model. Smaller, lighter, more compact,—using the same ultrasonic principles—it provides:

★**Simplified Operation** — fewer external controls

★**Rugged, Portable Construction** — can be carried right to the job, in shop or field.

With the Reflectoscope it is possible to find smaller defects at greater depths (up to 25 feet) than with any other non-destructive testing equipment. Cracks, voids, laminations and other defects are accurately located in billets, forgings, castings, etc., or in assembled shafts, axles, and other parts. Welds can also be tested with the Type SRO5 Reflectoscope.

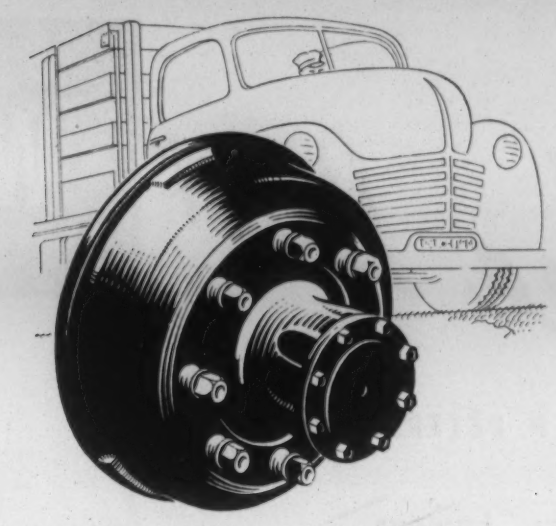
Write for Bulletin 3001-F-2 describing the Type SRO5 Reflectoscope.

SPERRY

SPERRY PRODUCTS, INC.

DANBURY, CONN.

For 20 years specialists in Non-Destructive Testing



Wear- and heat-resistance —together

The addition of Molybdenum to cast iron has specially applicable effects where good resistance to wear must be combined with least susceptibility to cracking under sudden changes of temperature.

Brake drums, for instance: here is a well-proved composition, 3.70% Total Carbon, 1.80% Silicon, 0.80% Manganese, with 0.50% Chromium and 0.70% Molybdenum added.

This is one of the many suitable economical compositions in our new booklet, "Applications of Molybdenum Cast Irons." The busy foundryman and engineer will find the alphabetical listing useful—write for a copy!

Climax Molybdenum Company

500 Fifth Avenue
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MOLY

MM-2 F 11

The Last WORD

by **FRED P. PETERS,** *Editorial Director*

The Editors' Lament

Tom Lippert of *The Iron Age,* Earl Shaner of *Steel,* and your correspondent were, it turns out, about the only members of the A.S.M.'s recent distinguished Committee of Award for the Salute to Alloy Steel who did not receive one of the coveted citations and certificates in October. The reason: More than one (1) vote was required for the naming of any person as an Award winner.

Never mind, boys. If they ever give one for sheer unadulterated (*i.e.* high-purity) brass, we editors will win it, every time!

Herman on Education

Dear F. P. P.:

Ever since you wrote that editorial in July 1947 about my troubles with too many magazines and all I have had to answer letters from various characters, chiefly engineers, asking for more details about my problems and how I worked them out. Most of them don't write much better than you or me, having also attended engineering colleges where English used to be like Latin, something you studied a couple of hours a week so that in later life you could read it if you had to but would never be required to speak or write it.

I am told however that there is now quite an improvement in the way our technical colleges and universities prepare their still unsuspecting students for the trials and tribulations of the outside world. Mostly they are emphasizing fundamentals and among the fundamentals you will now find not only basic chemistry and physics and calculus and mechanics and thermodynamics and strength of materials but also sociology, economics, business administration, English, technical writing, public speaking, life-and-living, etc.

The modern young B.S. will no doubt be able to balance a saucer of tea on one knee while enchanting a debutante on the other with a quick picture of the difference between the U-235 and the U-238 atoms. Words will come tripping off his tongue or pen like parts from a punch press, and he will be the soul of patience and understanding when management beseeches him to extricate them from the closing jaws of rising costs and disappearing markets.

But there is one field which needs more attention from the professors and that is the general area in which your monthly monstrosity operates. Most of the collegiate wars include a battle or two with engineering materials in which the student evidently goes down to ignominious defeat, judging by his later lack of mastery of the subject. This condition doubtless creates a lot of readers for your paper but it would be much better for everybody in industry if the "materials" courses in our halls of learning gave more attention to materials as used in the manufacture of industrial products and less to the design and construction of bridges, buildings, railroads, streets, etc. (except of course for civil and architectural engineers).

Even more than this, though, we need a lot of college-trained professional materials engineers. What we're getting now are good men with degrees in metallurgy or mechanical engineering or sometimes chemistry who later on become materials engineers through the pressure of events. Although there are twice as many "materials engineers" by title now as before the war and many more (like me) bearing other titles but doing mostly materials engineering work, there was no direct educational source for them; they're mostly all converted metallurgists or mechanical engineers.

I understand one university (Syracuse) is now giving a full curriculum leading to a degree in materials engineering. Maybe there are others. But there ought to be *several* others for the field strangely enough is growing and it would be a lot cheaper if industry could put young men directly into materials work without having to first teach them that cast iron doesn't always break when you drop it or that a factor of safety of 5 or 10 may keep a bridge neatly suspended in air but will never get an airplane off the ground.

Well, F. P. as you can see all this letter writing has tremendously improved my command of our native tongue as they say. In fact, with all the letters I have to answer on account of you I hope you will permit me to occasionally use your columns like this and thus kill all these birds with one stone.

Yours for more and better materials,
Herman

Nonferrous Iron

Our good friend, C. E. Herington, was somewhat startled, to put it mildly, when we inadvertently classed his favorite material (Meehanite) under "nonferrous metals" in the Manufacturers' Literature section for December. After being harassed for years by misspellings like Mechanite and meehanite and by inaccurate definitions such as malleable iron, cast alloy steel, etc., this must have seemed to Mr. H. like the proverbial straw itself.

Meehanite is, of course, as ferrous as the very iron of which it's made. There's no point in trying to explain away our curious classification by talking about the controlled graphite and silicon, and the sometimes-present nickel, chromium or molybdenum. It was a mistake and we apologize. All that glitters is not gold—including Meehanite, worthy metal that it is.

February Fillers

Got a bang out of Marc Grossmann's (Carnegie-Illinois) report that the first gas pipeline was made in England about 150 years ago, out of musket barrels. Sounds like the birth of the War Assets Corp. . . .

Frank (Inco) LaQue's Sea Horse Institute, with lapel pin and all, is now working out a suitable initiation ceremony for the future sons and daughters of Kuré Beach. Candidates must vow never to bathe in a salt spray test when real C. P. seawater is available, and must have completed 100 full exposure tests on the rate of scale formation on a Carolina mermaid's tail. . . .

Found another savant recently (Dr. C. H. Mathewson of Yale, no less) who agrees that metals, theoretically, ought to be 10 to 100 times stronger than they are. Beginning to wonder, though —how would we ever get them fabricated? It's tough enough now. . . .

How Jolly!

A young engineer from Mt. Holly
Made a furnace resistor of moly.
But he heated it bare
In the ambient air—
How sublime was the outcome, by golly!